Sta 4-(8)

APR 28 1997

ENGINEERING DATA TRANSMITTAL

1. EDT 617600

2. To: (Receiving Organization) Distribution	3. From: (Originating Organization) Data Assessment and Interpretation	4. Related EDT No.: N/A
5. Proj./Prog./Dept./Div.: Tank 241-S-111/Waste Management/DAI/Process Engineering	6. Design Authority/ Design Agent/Cog. Engr.: Jim G. Field	7. Purchase Order No.: N/A
8. Originator Remarks: This document is being released into the supporting document system for retrievability purposes.		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: 241-S-111
11. Receiver Remarks: For release.	11A. Design Baseline Document? [] Yes [X] No	12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: 04/28/97

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Designator	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	HNF-SD-WM-ER-638	N/A	0	Tank Characterization Report for Single-Shell Tank 241-S-111	N/A	2	1	1

16. KEY

Approval Designator (F)	Reason for Transmittal (G)		Disposition (H) & (I)	
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)	1. Approval 2. Release 3. Information	4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment	4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION
(See Approval Designator for required signatures)

(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN	(G) Reason	(H) Disp.	(J) Name (K) Signature (L) Date (M) MSIN
		Design Authority	1	1	R.J. Cash R.J. Cash 4/28/97 S7-14
		Design Agent	1	1	N.W. Kirch N.W. Kirch 4-28-97 R2-11
2	1	Cog.Eng. J.G. Field J.G. Field 4/28/97	1	1	J.G. Kristofzski JGK 4-28-97 R2-12
2	1	Cog. Mgr. K.M. Hall Kathleen M. Hall 4/28/97			
		QA			
		Safety			
		Env.			

18. A.E. Young Ann E. Young 4-28-97 Signature of EDT Originator Date	19. N/A Authorized Representative Date for Receiving Organization	20. K.M. Hall Kathleen M. Hall 4/28/97 Design Authority/ Cognizant Manager Date	21. DOE APPROVAL (if required) Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

BD-7400-172-2 (05/96) GEF097

INSTRUCTIONS FOR COMPLETION OF THE ENGINEERING DATA TRANSMITTAL

(USE BLACK INK OR TYPE)

BLOCK	TITLE	
(1)*	EDT	• Pre-assigned EDT number.
(2)	To: (Receiving Organization)	• Enter the individual's name, title of the organization, or entity (e.g., Distribution) that the EDT is being transmitted to.
(3)	From: (Originating Organization)	• Enter the title of the organization originating and transmitting the EDT.
(4)	Related EDT No.	• Enter EDT numbers which relate to the data being transmitted.
(5)*	Proj./Prog./Dept./Div.	• Enter the Project/Program/Department/Division title or Project/Program acronym or Project Number, Work Order Number or Organization Code.
(6)*	Design Authority (for Design Baseline Documents)/Cognizant Engineer (for all others)/Design Agent	• Enter the name of the individual identified as being responsible for coordinating disposition of the EDT.
(7)	Purchase Order No.	• Enter related Purchase Order (P.O.) Number, if available.
(8)*	Originator Remarks	• Enter special or additional comments concerning transmittal, or "Key" retrieval words may be entered.
(9)	Equipment/Component No.	• Enter equipment/component number of affected item, if appropriate.
(10)	System/Bldg./Facility	• Enter applicable system, building or facility number, if appropriate.
(11)	Receiver Remarks	• Enter special or additional comments concerning transmittal.
(11A)	Design Baseline Document	• Enter an "X" in the appropriate box. Consult with Design Authority for identification of Design Baseline Documents, if required.
(12)	Major Assm. Dwg. No.	• Enter applicable drawing number of major assembly, if appropriate.
(13)	Permit/Permit Application No.	• Enter applicable permit or permit application number, if appropriate.
(14)	Required Response Date	• Enter the date a response is required from individuals identified in Block 17 (Signature/Distribution).
(15)*	Data Transmitted	
	(A)* Item Number	• Enter sequential number, beginning with 1, of the information listed on EDT.
	(B)* Document/Drawing No.	• Enter the unique identification number assigned to the document or drawing being transmitted.
	(C)* Sheet No.	• Enter the sheet number of the information being transmitted. If no sheet number, leave blank.
	(D)* Rev. No.	• Enter the revision number of the information being transmitted. If no revision number, leave blank.
	(E) Title or Description of Data Transmitted	• Enter the title of the document or drawing or a brief description of the subject if no title is identified.
	(F)* Approval Designator	• Enter the appropriate Approval Designator (Block 15). Also, indicate the appropriate approvals for each item listed, i.e., SQ, ESQ, etc.
	(G) Reason for Transmittal	• Enter the appropriate code to identify the purpose of the data transmittal (see Block 16).
	(H) Originator Disposition	• Enter the appropriate disposition code (see Block 16).
	(I) Receiver Disposition	• Enter the appropriate disposition code (see Block 16).
(16)	Key	• Number codes used in completion of Blocks 15 (G), (H), and (I), and 17 (G), (H) (Signature/Distribution).
(17)	Signature/Distribution	
	(G) Reason	• Enter the code of the reason for transmittal (Block 16).
	(H) Disposition	• Enter the code for the disposition (Block 16).
	(J) Name	• Enter the signature of the individual completing the Disposition 17 (H) and the Transmittal.
	(K)* Signature	• Obtain appropriate signature(s).
	(L)* Date	• Enter date signature is obtained.
	(M)* MSIN	• Enter MSIN. Note: If Distribution Sheet is used, show entire distribution (including that indicated on Page 1 of the EDT) on the Distribution Sheet.
(18)	Signature of EDT Originator	• Enter the signature and date of the individual originating the EDT (entered prior to transmittal to Receiving Organization). If the EDT originator is the Design Authority (for Design Baseline Documents)/Cognizant Engineer (for all others) or Design Agent, sign both Blocks 17 and 18.
(19)	Authorized Representative for Receiving Organization	• Enter the signature and date of the individual identified by the Receiving Organization Design Authority (for Design Baseline Documents)/Cognizant Engineer (for all others) as authorized to approve disposition of the EDT and acceptance of the data transmitted, as applicable.
(20)*	Cognizant Manager	• Enter the signature and date of the cognizant manager. (This signature is authorization for release.) This signature is not required if the Design Authority is approving the document.
(21)*	DOE Approval	• Enter DOE approval (if required) by signature or control number that tracks the approval to a signature, and indicate DOE action.

*Asterisk denote the required minimum items check by Configuration Documentation prior to release; these are the minimum release requirements.

Tank Characterization Report for Single-Shell Tank 241-S-111

John M. Conner
Lockheed Martin Hanford Corp., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-87RL10930

EDT/ECN: EDT-617600 UC: 2070
Org Code: 74620 Charge Code: N4G4C
B&R Code: EW 3120074 Total Pages: 232

Key Words: Waste Characterization, Single-Shell Tank, SST, Tank 241-S-111, Tank S-111, S-111, S Farm, Tank Characterization Report, TCR, Waste Inventory, TPA Milestone M-44

Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-S-111. This report supports the requirements of the Tri-Party Agreement Milestone M-44-10.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America. To obtain copies of this document, contact: WHC/BCS Document Control Services, P.O. Box 1970, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

Kara M. Broz 4/28/97
Release Approval Date

DATE
STA 4
APR 28 1997
Release Stamp

Approved for Public Release

HNF-SD-WM-ER-638, Rev. 0
UC-2070

Tank Characterization Report for Single-Shell Tank 241-S-111

J. M. Conner
Lockheed Martin Hanford Corporation

R. D. Cromar
Numatec Hanford Corporation

R. E. Stout
R. T. Winward
Meier Associates

J. L. Stroup
Fluor Daniel Northwest

J. L. Huckaby
Pacific Northwest National Laboratory

Date Published
April 1997

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

Approved for public release; distribution is unlimited

CONTENTS

1.0 INTRODUCTION 1-1
1.1 SCOPE 1-1
1.2 TANK BACKGROUND 1-2

2.0 RESPONSE TO TECHNICAL ISSUES 2-1
2.1 SAFETY SCREENING 2-1
2.1.1 Exothermic Conditions (Energetics) 2-1
2.1.2 Flammable Gas 2-2
2.1.3 Criticality 2-3
2.2 ORGANIC WASTE ISSUES 2-3
2.2.1 Condensed Phase Organic Issues 2-3
2.2.2 Organic Data Quality Objective Vapor Issues 2-4
2.3 VAPOR SCREENING 2-5
2.4 HISTORICAL MODEL EVALUATION 2-5
2.5 WASTE COMPATIBILITY 2-6
2.6 OTHER TECHNICAL ISSUES 2-8
2.6.1 Heat Generation 2-8
2.6.2 Pretreatment 2-8
2.7 SUMMARY 2-9

3.0 BEST-BASIS STANDARD INVENTORY ESTIMATE 3-1

4.0 RECOMMENDATIONS 4-1

5.0 REFERENCES 5-1

APPENDIX A: HISTORICAL TANK INFORMATION A-1

A1.0 CURRENT TANK STATUS A-3

A2.0 TANK DESIGN AND BACKGROUND A-4

A3.0 PROCESS KNOWLEDGE A-8
A3.1 WASTE TRANSFER HISTORY A-8
A3.2 HISTORICAL ESTIMATION OF TANK CONTENTS A-9

A4.0 SURVEILLANCE DATA A-16
A4.1 SURFACE-LEVEL READINGS A-16
A4.2 INTERNAL TANK TEMPERATURES A-16
A4.3 TANK 241-S-111 PHOTOGRAPHS A-18

CONTENTS (Continued)

A5.0 TANK VOLUME ESTIMATES A-18
A5.1 SURFACE LEVEL AND WASTE VOLUME ESTIMATE A-18
A5.2 DRAINABLE LIQUID VOLUME ESTIMATE A-18
A5.3 ADDITIONAL VOLUME ESTIMATES A-19

A6.0 APPENDIX A REFERENCES A-19

APPENDIX B: SAMPLING OF TANK 241-S-111 . . . . B-1

B1.0 TANK SAMPLING OVERVIEW B-3

B2.0 1996 PUSH-MODE CORE SAMPLING EVENT B-4
B2.1 DESCRIPTION OF SAMPLING EVENT B-4
B2.2 SAMPLE HANDLING B-4
B2.3 SAMPLE ANALYSIS B-8
B2.4 CORE SAMPLING ANALYTICAL RESULTS B-14
B2.4.1 Radiochemical Analyses B-15
B2.4.2 Thermodynamic Analyses B-23
B2.4.3 Inorganic Analyses B-26
B2.4.4 Carbon Analyses B-73
B2.4.5 Physical Analyses B-76
B2.5 ASSESSMENT OF CHARACTERIZATION RESULTS B-77
B2.5.1 Field Observations B-77
B2.5.2 Quality Control Assessment B-78
B2.5.3 Data Consistency Checks B-78
B2.5.4 Mean Concentrations and Confidence Intervals B-82

B3.0 VAPOR SAMPLING RESULTS B-100
B3.1 STANDARD HYDROGEN MONITORING SYSTEM B-100
B3.2 VAPOR GRAB SAMPLES B-100
B3.3 HEATED VAPOR PROBE B-101
B3.3.1 Inorganic Gases and Vapors B-101
B3.3.2 Organic Vapors B-103

B4.0 HISTORICAL SAMPLE RESULTS B-108
B4.1 DESCRIPTION OF 1980 SAMPLE DATA B-108
B4.2 DESCRIPTION OF 1978 SAMPLE B-108
B4.3 DESCRIPTION OF 1976 SAMPLE B-108
B4.4 DESCRIPTION OF DECEMBER 1974 SAMPLE B-109
B4.5 DESCRIPTION OF AUGUST 1974 SAMPLE B-109

CONTENTS (Continued)

B4.6 DESCRIPTION OF MAY 1974 SAMPLE B-109
B4.7 DESCRIPTION OF 1971 SAMPLE B-109

B5.0 APPENDIX B REFERENCES B-125

APPENDIX C: STATISTICAL ANALYSIS FOR ISSUE RESOLUTION C-1

C1.0 STATISTICS FOR SAFETY SCREENING DATA QUALITY OBJECTIVE C-3

C2.0 STATISTICS FOR THE ORGANIC DATA QUALITY OBJECTIVE C-5

C3.0 APPENDIX C REFERENCES C-8

APPENDIX D: EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-S-111 . . . . . D-1

D1.0 CHEMICAL INFORMATION SOURCES D-3

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES D-3

D3.0 COMPONENT INVENTORY EVALUATION D-5
D3.1 WASTE HISTORY TANK 241-S-111 . . . . . D-5
D3.2 EVALUATION OF TANK WASTE VOLUME D-5
D3.3 CONTRIBUTING WASTE TYPES D-6
D3.4 INVENTORY EVALUATION D-6
D3.5 BASIS FOR CALCULATIONS USED IN THIS ENGINEERING EVALUATION D-7
D3.5.1 Basis for Saltcake Calculations D-7
D3.5.2 Basis for Sludge Calculations D-10
D3.6 ESTIMATED COMPONENT INVENTORIES D-12

D4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES D-14
D4.1 OVERVIEW D-14
D4.2 CALCULATION OF THE BEST-BASIS INVENTORY D-15

D5.0 APPENDIX D REFERENCES D-18

APPENDIX E: BIBLIOGRAPHY FOR TANK 241-S-111 . . . . . E-1

LIST OF FIGURES

A2-1 Riser Configuration for Tank 241-S-111 . . . . A-6

A2-2 Tank 241-S-111 Cross Section and Schematic A-7

A3-1 Tank Layer Model for Tank 241-S-111 . . . . A-11

A4-1 Tank Level History for Tank 241-S-111 . . . . A-17

LIST OF TABLES

1-1 Summary of Recent Sampling 1-2

1-2 Description of Tank 241-S-111 1-3

2-1 Comparison of Core Sample Data to Historical Waste Streams 2-6

2-2 Waste Compatibility Data Quality Objective Criteria 2-7

2-3 Heat Load Estimate Based on Data from 1996 Core Sample 2-8

2-4 Summary of Safety Screening, Organic, Historical, and Compatibility DQO Results 2-10

3-1 Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-S-111 3-3

3-2 Best-Basis Inventory Estimates for Radioactive Components in Tank 241-S-111 . . 3-4

4-1 Acceptance of Tank 241-S-111 Sampling and Analysis 4-1

4-2 Acceptance of Evaluation of Characterization Data and Information for Tank 241-S-111 4-2

A1-1 Tank Contents Status Summary A-4

A2-1 Tank 241-S-111 Risers A-5

A3-1 Tank 241-S-111 Major Waste Transfers A-9

A3-2 Historical Tank Inventory Estimate - Analytes A-12

A3-3 Historical Tank Inventory Estimate - Radionuclides A-14

B2-1 Integrated Data Quality Objective Requirements for Tank 241-S-111 . . . . . B-5

B2-2 Tank 241-S-111 Subsampling Scheme and Sample Description B-6

B2-3 Tank 241-S-111 Sample Analysis Summary B-8

B2-4 Preparatory and Analytical Procedures B-13

B2-5 Analytical Presentation Tables B-14

LIST OF TABLES (Continued)

B2-6 Tank 241-S-111 Analytical Results: Total Alpha B-16

B2-7 Tank 241-S-111 Analytical Results: Total Beta B-17

B2-8 Tank 241-S-111 Analytical Results: Strontium-89/90 . . . . B-17

B2-9 Tank 241-S-111 Analytical Results: Americium-241 (GEA) B-18

B2-10 Tank 241-S-111 Analytical Results: Cesium-137 (GEA) B-19

B2-11 Tank 241-S-111 Analytical Results: Cobalt-60 (GEA) B-20

B2-12 Tank 241-S-111 Analytical Results: Europium-154 (GEA) B-21

B2-13 Tank 241-S-111 Analytical Results: Europium-155 (GEA) B-22

B2-14 Tank 241-S-111 Analytical Results: Plutonium-239/40 . . . . B-23

B2-15 Tank 241-S-111 Analytical Results: Americium-241 . . . . B-23

B2-16 Tank 241-S-111 Analytical Results: Exotherm (DSC) B-24

B2-17 Tank 241-S-111 Analytical Results: Percent Water (DSC/TGA) B-25

B2-18 Tank 241-S-111 Analytical Results: Bromide (IC) B-26

B2-19 Tank 241-S-111 Analytical Results: Chloride (IC) B-27

B2-20 Tank 241-S-111 Analytical Results: Fluoride (IC) B-28

B2-21 Tank 241-S-111 Analytical Results: Nitrate (IC) B-29

B2-22 Tank 241-S-111 Analytical Results: Nitrite (IC) B-30

B2-23 Tank 241-S-111 Analytical Results: Oxalate (IC) B-31

B2-24 Tank 241-S-111 Analytical Results: Phosphate (IC) B-32

B2-25 Tank 241-S-111 Analytical Results: Sulfate (IC) B-33

B2-26 Tank 241-S-111 Analytical Results: Aluminum (ICP) B-35

LIST OF TABLES (Continued)

B2-27 Tank 241-S-111 Analytical Results: Antimony (ICP) B-36

B2-28 Tank 241-S-111 Analytical Results: Arsenic (ICP) B-37

B2-29 Tank 241-S-111 Analytical Results: Barium (ICP) B-38

B2-30 Tank 241-S-111 Analytical Results: Beryllium (ICP) B-39

B2-31 Tank 241-S-111 Analytical Results: Bismuth (ICP) B-40

B2-32 Tank 241-S-111 Analytical Results: Boron (ICP) B-41

B2-33 Tank 241-S-111 Analytical Results: Cadmium (ICP) B-42

B2-34 Tank 241-S-111 Analytical Results: Calcium (ICP) B-43

B2-35 Tank 241-S-111 Analytical Results: Cerium (ICP) B-44

B2-36 Tank 241-S-111 Analytical Results: Chromium (ICP) B-45

B2-37 Tank 241-S-111 Analytical Results: Cobalt (ICP) B-46

B2-38 Tank 241-S-111 Analytical Results: Copper (ICP) B-47

B2-39 Tank 241-S-111 Analytical Results: Iron (ICP) B-48

B2-40 Tank 241-S-111 Analytical Results: Lanthanum (ICP) B-49

B2-41 Tank 241-S-111 Analytical Results: Lead (ICP) B-50

B2-42 Tank 241-S-111 Analytical Results: Lithium (ICP) B-51

B2-43 Tank 241-S-111 Analytical Results: Magnesium (ICP) B-52

B2-44 Tank 241-S-111 Analytical Results: Manganese (ICP) B-53

B2-45 Tank 241-S-111 Analytical Results: Molybdenum (ICP) B-54

B2-46 Tank 241-S-111 Analytical Results: Neodymium (ICP) B-55

B2-47 Tank 241-S-111 Analytical Results: Nickel (ICP) B-56

LIST OF TABLES (Continued)

B2-48 Tank 241-S-111 Analytical Results: Phosphorus (ICP) B-57

B2-49 Tank 241-S-111 Analytical Results: Potassium (ICP) B-58

B2-50 Tank 241-S-111 Analytical Results: Samarium (ICP) B-59

B2-51 Tank 241-S-111 Analytical Results: Selenium (ICP) B-60

B2-52 Tank 241-S-111 Analytical Results: Silicon (ICP) B-61

B2-53 Tank 241-S-111 Analytical Results: Silver (ICP) B-62

B2-54 Tank 241-S-111 Analytical Results: Sodium (ICP) B-63

B2-55 Tank 241-S-111 Analytical Results: Strontium (ICP) B-64

B2-56 Tank 241-S-111 Analytical Results: Sulfur (ICP) B-65

B2-57 Tank 241-S-111 Analytical Results: Thallium (ICP) B-66

B2-58 Tank 241-S-111 Analytical Results: Titanium (ICP) B-67

B2-59 Tank 241-S-111 Analytical Results: Total Uranium (ICP) B-68

B2-60 Tank 241-S-111 Analytical Results: Vanadium (ICP) B-69

B2-61 Tank 241-S-111 Analytical Results: Zinc (ICP) B-70

B2-62 Tank 241-S-111 Analytical Results: Zirconium (ICP) B-71

B2-63 Tank 241-S-111 Analytical Results: Total Uranium (U) B-72

B2-64 Tank 241-S-111 Analytical Results: Hydroxide (OH Direct) B-72

B2-65 Tank 241-S-111 Analytical Results: pH Measurement B-73

B2-66 Tank 241-S-111 Analytical Results: Ammonia
(Ion Selective Electrode) B-73

B2-67 Tank 241-S-111 Analytical Results: Total Inorganic Carbon B-74

B2-68 Tank 241-S-111 Analytical Results: Total Organic Carbon B-75

LIST OF TABLES (Continued)

B2-69 Tank 241-S-111 Analytical Results: Bulk Density B-76

B2-70 Tank 241-S-111 Analytical Results: Specific Gravity B-77

B2-71 Comparison of Oxalate and TOC Data B-79

B2-72 Cation Mass and Charge Data for Segment-Level Liquids B-80

B2-73 Anion Mass and Charge Data for Segment-Level Liquids B-81

B2-74 Cation Mass and Charge Data for Composite Solids B-82

B2-75 Anion Mass and Charge Data for Composite Solids B-82

B2-76 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data B-84

B2-77 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Solid Segment Sample Data B-91

B2-78 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Liquid Segment Sample Data B-95

B3-1 Results from Vapor Grab Samples from Tank 241-S-111 . . . . B-100

B3-2 Tank 241-S-111 Inorganic Gas and Vapor Data B-102

B3-3 Tank 241-S-111 Quantitatively Measured Organic Compounds in SUMMA™ Samples B-104

B3-4 Tank 241-S-111 Quantitatively Measured Organic Compounds in TST Samples B-105

B3-5 Tank 241-S-111 Positively Identified Organic Compounds in TST Samples . . . B-105

B4-1 Tank 241-S-111 Data Reported September 18, 1980 . . . . B-110

B4-2a 1978 Core Sample Data, Sample 1001-C B-112

B4-2b 1978 Core Sample Data, Samples 1003-C and 1004-C B-114

B4-2c 1978 Core Sample Data, Sample 1009-C B-116

LIST OF TABLES (Continued)

B4-2d 1978 Core Sample Data, Sample 1009-C Supernatant B-118

B4-2e 1978 Core Sample Data, Analysis of Supernatant B-119

B4-3 Tank 241-S-111 Data Sampled December 27, 1976 . . . . B-120

B4-4 Tank 241-S-111 Sample Data, December 16, 1974. . . . . B-121

B4-5 Tank 241-S-111 Analytical Data Reported August 23, 1974 . . . . B-122

B4-6 Tank 241-S-111 Data Reported May 29, 1974 . . . . B-123

B4-7 Tank 241-S-111 Data Reported September 21, 1971 . . . . B-124

C1-1 95 Percent Confidence Interval Upper Limits for Alpha for Tank 241-S-111 . . . C-4

C1-2 95 Percent Confidence Interval Upper Limits for DSC for Tank 241-S-111 . . . C-4

C1-3 95 Percent Confidence Interval Lower Limits for Percent Water for Tank 241-S-111 . . . . C-6

C1-4 95 Percent Confidence Interval Upper Limits for TOC for Tank 241-S-111 . . . C-7

D2-1 Sample-Based and Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-S-111 . . . . D-4

D2-2 Sampling and HDW Predicted Inventory Estimates for Radioactive Components in Tank 241-S-111 . . . . D-5

D3-1 Engineering Evaluation Approaches Used On Tank 241-S-111 . . . . D-7

D3-2 SMMS1 Saltcake Concentrations from Sampling Data and Modeling D-8

D3-3 R1/CWR1 Sludge Concentrations from Sampling Data and Modeling D-10

D3-4 Estimated Chemical Inventory for Tank 241-S-111 . . . . D-12

D4-1 Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-S-111 . . . . D-16

D4-2 Best-Basis Inventory Estimates for Radioactive Components in Tank 241-S-111. . . . . D-17

LIST OF TERMS

ANOVA	analysis of variance
Btu/hr	British thermal units per hour
CAS	Chemical Abstract Service
Ci	curies
Ci/g	curies per gram
Ci/L	curies per liter
CI	confidence interval
cm	centimeters
cm^3	cubic centimeters
conc.	concentration
CWR	REDOX cladding waste
CWR1	REDOX cladding waste from 1952 to 1960
df	degrees of freedom
DL	detectable limit
DQO	data quality objective
DSC	differential scanning calorimetry
DST	double-shell tank
DTA	differential thermal analysis
EB	evaporator bottoms
EPA	Environmental Protection Agency
FIC	Food Instrument Corporation
ft	feet
ft^2	square feet
g/cm^3	grams per cubic centimeter
g/g	grams per gram
g/gal	grams per gallon
g	grams
g/L	grams per liter
g/mL	grams per milliliter
GC	gas chromatograph
GEA	gamma energy analysis
HDW	Hanford defined waste
IC	ion chromatography
ICP	inductively coupled plasma spectroscopy
in.	inches
J/g	joules per gram
kg/cm^2	kilograms per cubic centimeter
kg	kilograms
kgal	kilogallons
kg/L	kilograms per liter
kL	kiloliters
kW	kilowatts

LIST OF TERMS (Continued)

LANL	Los Alamos National Laboratory
LFL	lower flammability limit
LL	lower limit
m	meters
m^2	square meters
M	moles per liter
mg	milligrams
mg/g	milligrams per gram
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mm	millimeters
mRad/hr	millirads per hour
MS	mass spectrometer
n/r	not reported
n/a	not applicable
nCi/g	nanocuries per gram
NPH	normal paraffin hydrocarbons
OH	free hydroxide
ORNL	Oak Ridge National Laboratory
pH	hydrogen potential
PHMC	Project Hanford Management Contractor
PNNL	Pacific Northwest National Laboratory
ppm	parts per million
ppmv	parts per million volume
psi	pounds per square inch
QC	quality control
R1	REDOX waste generated between 1952 and 1957
REDOX	reduction-oxidation
REML	restricted maximum likelihood estimation
RPD	relative percent difference
RSD	relative standard deviation
S1SltCk	Salt slurry produced in the 242-S Evaporator
SACS	Surveillance Analysis Computer System
SAP	sampling and analysis plan
SHMS	Standard Hydrogen Monitoring System
SMM	supernatant mixing model
SMMS1	concentrated supernatant solids
SOWRT	sort on radioactive waste type
SpG	specific gravity
SU	supernatant

LIST OF TERMS (Continued)

TCP	tank characterization plan
TCR	tank characterization report
TGA	thermogravimetric analysis
TIC	total inorganic carbon
TLM	tank layer model
TOC	total organic carbon
TRU	transuranic
TST	triple sorbent trap
TWRS	Tank Waste Remediation System
UL	upper limit
VSS	Vapor Sampling System
W/Ci	watts per curie
W	watts
watts/L	watts per liter
WSTRS	waste status and transaction record summary
wt%	weight percent
°C	degrees Celsius
°F	degrees Fahrenheit
μCi/g	microcuries per gram
μCi/gal	microcuries per gallon
μCi/L	microcuries per liter
μCi/mL	microcuries per milliliter
μeq/μg	microequivalents per microgram
μeq/mL	microequivalents per milliliter
μeq/g	microequivalents per gram
μg/mL	micrograms per milliliter
μg/g	micrograms per gram
μg C/g	micrograms carbon per gram
μwatt/g	microwatts per gram

This page intentionally left blank.

1.0 INTRODUCTION

One of the major functions of the Tank Waste Remediation System (TWRS) is to characterize wastes in support of waste management and disposal activities at the Hanford Site. Analytical data from sampling and analysis, along with other available information about a tank, are compiled and maintained in a tank characterization report (TCR). This report and its appendixes serve as the TCR for single-shell tank 241-S-111. The objectives of this report are: 1) to use characterization data to address technical issues associated with tank 241-S-111 waste; and 2) to provide a standard characterization of this waste in terms of a best-basis inventory estimate. The response to technical issues is summarized in Section 2.0, and the best-basis inventory estimate is presented in Section 3.0. Recommendations regarding safety status and additional sampling needs are provided in Section 4.0. Supporting data and information are contained in the appendixes. This report also supports the requirements of *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996) milestone M-44-10.

1.1 SCOPE

Characterization information presented in this report originated from sample analyses and known historical sources. While only the results of recent sample events will be used to fulfill the requirements of the data quality objectives (DQOs), other information can be used to support (or question) conclusions derived from these results. Historical information for tank 241-S-111, provided in Appendix A, includes surveillance information, records pertaining to waste transfers and tank operations, and expected tank contents derived from a process knowledge model.

The recent sampling events listed in Table 1-1, as well as sample data obtained prior to 1989, are summarized in Appendix B along with the sampling results. The results of the 1996 core sampling event, also reported in the laboratory data package (Steen 1996), did not satisfy the data requirements specified in *Tank 241-S-111 Push Mode Core Sampling and Analysis Plan* (Conner 1996). Only one of the two planned core samples could be retrieved. The statistical analysis and numerical manipulation of data used to address programmatic issues are reported in Appendix C. Appendix D contains the evaluation to establish the best basis for the inventory estimate and the statistical analysis performed for this evaluation. A bibliography that resulted from an in-depth literature search of all known information sources applicable to tank 241-S-111 and its respective waste types is contained in Appendix E. The reports listed in Appendix E may be found in the Lockheed Martin Hanford Corporation Tank Characterization Resource Center.

Table 1-1. Summary of Recent Sampling.

Sample/date	Phase	Location	Segmentation	Percent Recovery
Vapor sample (March 21, 1995)[1]	Gas	Tank headspace, through riser 14	n/a	n/a
Core 149 (May 15 to May 21, 1996)	Liquid and solid	Riser 8	1 through 11	68 - 100
Core 150 (June 14 to June 19, 1996)	Liquid and solid	Riser 14	1, 2, 3, 3A, 3B, 3C, and 3D	0 - 100
Vapor sample (grab samples, July 11 to August 7, 1995)	Gas	Tank headspace, through riser 14	n/a	n/a
H_2 monitoring[2] (August 1995 to present)	Gas	Tank headspace, through riser 14	n/a	n/a

Notes:

n/a = not applicable

[1]Vapor Sampling System (heated vapor probe)
[2]Standard Hydrogen Monitoring System (SHMS)

1.2 TANK BACKGROUND

Tank 241-S-111 is located in the 200 West Area S Tank Farm on the Hanford Site. It is the second tank in a three-tank cascade series. The tank went into service in 1952 when it received high-level reduction-oxidation (REDOX) waste cascaded from tank 241-S-110. The tank received high-level REDOX waste and REDOX cladding waste intermittently until 1957. A small transfer of cladding waste was received from tank 241-S-107 in 1965. From 1974 to 1975, waste from the tank was pumped to tank 241-S-102 for evaporator feed. Evaporator bottoms were returned to the tank intermittently over this time period. Salt well liquor was pumped from the tank from 1976 to 1978, but was stopped after an equipment failure. Additional salt well pumping must be performed prior to stabilization. The tank was removed from service and declared inactive in 1976. The tank is sound.

A summary description of tank 241-S-111 and its contents is presented in Table 1-2. The tank has an operating capacity of 2,870 kL (758 kgal), and presently contains an estimated 2,040 kL (540 kgal) of non-complexed waste (see Appendix A, Section A5.0). The tank is on the Organic and Flammable Gas Watch Lists (Public Law 101-510).

Table 1-2. Description of Tank 241-S-111.

TANK DESCRIPTION	
Type	Single-shell
Constructed	1950-1951
In-service	1952
Diameter	22.9 m (75.0 ft)
Operating depth	7.3 m (24 ft)
Capacity	2,870 kL (758 kgal)
Bottom shape	Dish
Ventilation	Passive
TANK STATUS	
Waste classification	Non-complexed
Total waste volume	2,040 kL (540 kgal)
Supernatant volume	87 kL (23 kgal)
Saltcake volume	1,430 kL (378 kgal)
Sludge volume	526 kL (139 kgal)
Drainable interstitial liquid volume	621 kL (164 kgal)
Waste surface level (January 21, 1997)	5.18 m (203.8 in.)
Temperature (January 1991 to October 1996)	18.4 °C (65.2 °F) to 36 °C (97 °F)
Integrity	Sound
Watch Lists	Flammable Gas and Organic Salts
SAMPLING DATE	
Push-mode core sampling	May-June 1996
Vapor sampling (Vapor Sampling System)	March 21, 1995
Vapor sampling (grab sampling)	July-August 1995
SERVICE STATUS	
Declared inactive	1976
Interim stabilization	Not yet stabilized
Intrusion prevention	Not completed

This page intentionally left blank.

2.0 RESPONSE TO TECHNICAL ISSUES

Five technical issues have been identified for tank 241-S-111 (Brown et al. 1996):

- **Safety screening**: Does the waste pose or contribute to any recognized potential safety problems?

- **Organic salts**: Are there organic complexants in concentrations above the level of concern?

- **Vapor screening**: Is the vapor in the tank flammable? Does the vapor pose a risk to workers' health? Does an organic solvent pool exist in the tank?

- **Historical model evaluation**: Is the waste inventory generated by a model based on process knowledge and historical information (Agnew et al. 1996) representative of the current tank waste inventory?

- **Waste compatibility**: Is the liquid waste in the tank compatible with the waste in the double-shell tank (DST) system?

The tank characterization plan (TCP) (Conner and Winkelman 1996) provides the types of sampling and analyses used to address the above issues. These five issues are addressed in the following sections, using data from the recent analysis of one core sample, tank headspace measurements, and available historical information. The sample and analysis data for tank 241-S-111 are provided in Appendix B. Other technical issues, such as heat generation in the waste, are also addressed.

2.1 SAFETY SCREENING

The data needed to screen the waste in tank 241-S-111 for potential safety problems is documented in *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995). These potential safety problems are exothermic conditions in the waste, flammable gases in the waste and/or tank headspace, and criticality conditions in the waste. Each of these conditions is addressed separately below.

2.1.1 Exothermic Conditions (Energetics)

The first requirement outlined in the safety screening DQO (Dukelow et al. 1995) is to ensure that there is not enough fuel in tank 241-S-111 to pose a safety hazard. Because of this requirement, tank samples were evaluated for energetics. The threshold limit for energetics is 480 J/g on a dry weight basis. Results obtained using differential scanning calorimetry indicated that exotherms were apparent in 6 of the 19 subsamples from core 149.

No exotherm was detected in any liquid sample. The largest exotherm was 141.9 μg/g (dry weight basis) for the segment 3 solids subsample. Sample results are compared to the limit using the one-sided, upper 95 percent confidence interval. The highest 95 percent upper confidence limit on the mean was 209.5 μg/g on a dry basis, which is well below the action limit of 480 J/g. These calculations are presented in Appendix C.

The safety screening DQO required that the waste sample profile be tested for energetics every half segment [24 cm (9.5 in.)] to determine if the energetics exceed the safety threshold limit. This requirement is considered to be met for core 149 (although segments 10 and 11 were not subsampled into half segments because of incomplete recovery).

In the absence of other information, the safety screening DQO required two vertical profiles of the waste in the tank. This requirement was not met. Although core 149 was a full-depth core, core 150 was incomplete. Only 2 of the 11 planned segments were recovered. None of the samples from core 150 were analyzed.

2.1.2 Flammable Gas

An SHMS has been installed in tank 241-S-111 to monitor the hydrogen concentration in the headspace. The monitoring system has been operating since August 21, 1995. The highest concentration of hydrogen reported for the tank is 1,270 ppm on December 14, 1995 (Wilkins et al. 1996). In addition, several grab samples were taken through the SHMS in July and August of 1995 and analyzed. The hydrogen concentrations in these samples varied from less than 5 ppm to 210 ppm (Wilkins et al. 1996).

A vapor sample was taken on March 21, 1995 via the Vapor Sampling System. Analyses indicated that the ammonia concentration was 122 ppm and the hydrogen concentration was 391 ppm. The total concentration of positively identified organic compounds was 0.75 ppm (Huckaby and Bratzel 1995).

The lower flammability limit (LFL) for hydrogen in air is 40,000 ppm, and the LFL for ammonia is 150,000 ppm. The action level stated in the safety screening DQO is 25 percent of the LFL (by gas specific monitoring gauges or gas chromatography/mass spectrometry). Wilkins et al. (1996) gives an action limit for hydrogen of 6,250 ppm, adjusted to account for the effect of other flammable gases. All reported results for this tank are well below this action limit. The results are variable, indicating that the concentration of hydrogen in the headspace fluctuates. Wilkins et al. (1996) estimates that the tank is at 1.1 percent of the LFL, based on data from the March 21, 1995 vapor sample. These data indicate that there is not a flammability concern for tank 241-S-111. Data from these vapor phase measurements are presented in Appendix B.

2.1.3 Criticality

Drainable liquids and solids from each segment of core 149 were analyzed for total alpha activity in accordance with the safety screening DQO (Dukelow et al. 1995). Density was also measured on the solid subsamples from each segment in accordance with this DQO. The safety threshold limit is 1 g ^{239}Pu per liter of waste. Assuming that all alpha is from ^{239}Pu and assuming a density of 1.87 g/mL (the highest result measured for the core samples), 1 g/L of ^{239}Pu is equivalent to 32.9 μCi/g of alpha activity.

As required by the DQO, the upper limit of the one-sided 95 percent confidence interval of the mean for each subsample was calculated. The highest result for total alpha was 0.207 μCi/g, or more than 100 times below the calculated limit. The method used to calculate confidence limits is contained in Appendix C. The drainable liquid samples from core 149 (segments 1, 2, and 3) were also analyzed for $^{239/240}$Pu. All results were below detection limits. The highest detection limit value was 7.62E-05 μCi/mL.

All results are well below the action limit, suggesting that the waste does not pose a criticality hazard. However, because two full-length profiles were not obtained, the criticality issue cannot be closed.

2.2 ORGANIC WASTE ISSUES

2.2.1 Condensed Phase Organic Issues

Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue (Turner et al. 1995), describes the concern that organic complexants were used during the major operational periods of the Hanford Site plants. Nitrate salts have also been precipitated in the tanks, and an intimate mixture of the complexants with the nitrate/nitrite may exist in some of the storage tanks. These salts may serve as an oxidizer which, when mixed with sufficiently high concentrations of organic complexants, could react exothermically if heated to high temperatures. Such a reaction could lead to a radioactive release from the tanks. Therefore, the potential for exothermic organic complexant reactions needs to be examined.

Review of the waste transfer records (Anderson 1990) indicates that REDOX waste was added to the tank in the 1950s and evaporated wastes were added in the 1970s. Partially neutralized waste and noncomplexed waste also were added in the late 1970s. The evaporated wastes may have contained organic complexants used in waste fractionation at B-Plant (complexant wastes were sent to the 242-S Evaporator in the 200 West Area for waste volume reduction).

According to the organic DQO, tanks suspected to contain organic complexants should be evaluated to determine whether sufficient fuel exists to support a propagating reaction. Differential scanning calorimetry and total organic carbon (TOC) analyses are prescribed. Differential scanning calorimetry was applied to liquid subsamples and homogenized half segments of the solids from core 149. Results are discussed above in Section 2.1.1. All results were well below the action limit.

The organic DQO also establishes an action limit of 30,000 μg/g TOC (dry weight basis). Sample results above that limit trigger further analyses to better determine the fuel content of the waste. The results from analyzing samples from core 149 indicate that the maximum TOC concentration was 6,430 μg/g (dry basis) in the segment 3 solid subsample. The highest 95 percent confidence interval result (on a dry basis) for a single subsample was 16,100 μg/g, which is still well below the action limit.

None of the data suggest that there is a concern of a propagating reaction in the waste. However, the issue cannot be closed because only one full-length profile of the waste was obtained (two full-length cores required to address the issue).

2.2.2 Organic Data Quality Objective Vapor Issues

Cash (1996) directed a change to the organic DQO to assess whether an organic solvent pool greater than 1 m^2 (10.8 ft^2) exists in any of the tanks. This memo dictates that tank vapors are to be analyzed for total non-methane hydrocarbons to determine whether an organic solvent pool exists on the tank surface.

Because the March 1995 vapor sampling and analysis preceded the Cash (1996) directive, a total non-methane hydrocarbons analysis was not performed. However, Huckaby et al. (1997) used semi-volatile organic data from tank 241-S-111 to estimate that an organic liquid pool of 0.08 m^2 (0.86 ft^2) might exist. The upper 95 percent confidence level calculation was 0.18 m^2 (1.93 ft^2); both figures are well below the limit of 1 m^2 stated by Cash (1996).

No further action is considered necessary to satisfy the Cash (1996) letter. However, if vapor sampling is necessary for another reason, then an analysis for total non-methane hydrocarbons should be considered. Vapor analytical data are presented in Appendix B.

2.3 VAPOR SCREENING

Data Quality Objectives for Tank Hazardous Vapor Safety Screening (Osborne and Buckley 1995) describes parameters for data collection to ensure appropriate conclusions can be drawn based on headspace vapor measurements. This DQO requires that tanks be sampled to evaluate vapor flammability and to identify and quantify compounds of toxicological concern. Compounds of toxicological concern are assigned a consensus exposure standard, which is generally the most stringent of known regulatory or recommended toxicological values for the occupational setting. For those constituents with unknown toxicological values, the consensus exposure standard was developed by the Westinghouse Hanford Company Vapor Review Committee (Osborne and Buckley 1995).

Tank 241-S-111 was sampled on March 21, 1995 according to an earlier revision of the Vapor DQO (Osborne et al. 1995). Sampling was conducted with the Vapor Sampling System, which uses a heated vapor probe to sample gases from the tank. Flammability results are discussed above in Section 2.1.2. All results are well below action limits. Huckaby and Bratzel (1995) reported that no headspace constituents exceeded the industrial hygiene notification limits (consensus exposure standards) specified in the *Vapor Sampling and Analysis Plan* (Homi 1995). Tank vapors are no longer being evaluated as a health concern (Hewitt 1996). Vapor data are presented in Appendix B.

2.4 HISTORICAL MODEL EVALUATION

The purpose of the historical evaluation is to determine whether the model based on process knowledge and historical information (Agnew et al. 1996) predicts tank inventories that are in agreement with sampling data. If the historical model can be shown to accurately predict the waste characteristics as observed through sample characterization, then there is a possibility that the amount of total sampling and analysis needed may be reduced.

Data requirements for this evaluation are documented in *Historical Model Evaluation Data Requirements* (Simpson and McCain 1996). Because tank 241-S-111 is considered a "spatially complex tank," specific waste types are not required to be investigated. Rather, a specified set of analyses are completed on all solid subsamples, along with a larger set of analyses on composites of each core. These analyses are expected to indicate where different waste layers are within the tank and provide overall tank composition data for comparison to the predicted inventory from the historical model.

Inspection of the data reveals that at least three distinct layers are present in the tank: 1) a liquid pool; 2) a high-sodium, high-nitrate saltcake layer that constitutes the bulk of the solids; and 3) a high aluminum sludge layer on the bottom. In Table 2-1, the two solid layers are compared to the waste types predicted to be in the tank by the tank layer model (TLM). The data indicate that the saltcake is consistent with the S1 saltcake waste type. The sludge results appear much closer to REDOX cladding waste (CWR) than REDOX sludge.

The data from tank 241-S-111 will be used in multi-tank statistical comparisons of sampling data and modeling predictions that are beyond the scope of this TCR. Because the historical DQO requires analysis of at least two profiles of the waste, additional sampling is required to satisfy the DQO.

Table 2-1. Comparison of Core Sample Data to Historical Waste Streams.

Analyte	Unit	Core 149 Seg. 4-8	S1 Saltcake[1]	Core 149 Seg. 10-11	CWR[1]	REDOX Sludge[1]
Na	ppm	216,000[2]	195,400	69,000[3]	52,500	33,000
Al	ppm	15,000[2]	31,000	249,000[3]	114,000	58,200+
Fe	ppm	-	-	< 1100[3]	-	38,100+
Cr	ppm	5,460[2]	3,000	2,685[3]	-	30,600+
H_2O	percent	29.9	32.1	11.1	69.4	44+
NO_3	ppm	281,000	274,300	-	-	-
CO_3	ppm	61,700	17,000	4,690	-	8,700
SO_4	ppm	22,000	13,000	-	-	-
^{137}Cs	μCi/g	-	-	67.7	-	41+
^{90}Sr	μCi/g	-	-	-	-	94+
U	ppm	-	-	< 11,000[3,4]	28,200	3,500+

Notes:

[1]Simpson and McCain (1996)
[2]Acid digest - inductively coupled plasma spectroscopy (ICP) results
[3]Fusion digest - ICP results
[4]Acid digestion results were < 235 ppm

2.5 WASTE COMPATIBILITY

Liquid will be pumped from tank 241-S-111 to stabilize the tank by removing the threat of significant leakage. Therefore, the requirements of the *Data Quality Objectives for Tank Farms Waste Compatibility Program* (Fowler 1995) were applied to liquids recovered from the core samples. The DQO requires data on wastes being transferred into or within the DST system in order to ensure that no safety problems are created as a result of commingling wastes and to maintain continued operability during waste transfer and waste concentration/ minimization (e.g. waste does not plug transfer piping, trap flammable gas, promote exothermic reactions, corrode lines or tanks, or thermally stress tanks).

Compatibility analyses are typically performed on liquid grab samples. However, for tank 241-S-111, analyses were performed on drainable liquid subsamples from core 149. Results were compared against the decision rules stated in the compatibility DQO. No results exceeded action limits derived from the compatibility DQO and stated in the sampling plan (Conner 1996). In Table 2-2, the data from core 149 liquids are compared to the applicable compatibility limits. No comparison is made if information on the receiver tank is necessary to determine compatibility.

Table 2-2. Waste Compatibility Data Quality Objective Criteria.[1]

Issue	Program Requirement[2]	Analytical Result[3]
Criticality	Pu $\leq$ 0.013 g/L	< 3.14E-6 g/L[4]
Flammable gas accumulation	Specific gravity < 1.3 or commingled waste < 1.41	1.36
Energetics	Exotherm/endotherm ratio < 1	0 (no exotherms)
	No separable organic phase	no separable organics
TRU segregation	TRU < 100 nCi/g	< 0.41 nCi/g (sum of $^{239/240}Pu$ and ^{241}Am)
Corrosion control[5]	If $NO_3 < 1.0M$: then $0.01M < OH < 8.0M$ and $0.011M \leq NO_2 \leq 5.5M$	$OH = 0.24M$ $NO_2 = 1.45M$ $NO_3 = 3.11M$
	If $1.0 < NO_3 \leq 3.0M$: then $0.1 \times NO_3 \leq OH < 10M$ and $OH + NO_2 \geq 0.4 \times NO_3$	
	For $NO_3 > 3.0M$: then $0.3M \leq OH < 10M$ and $OH + NO_2 \geq 1.2M$ and $NO_3 \leq 5.5M$	OH slightly below this limit; however, these limits do not apply to single-shell tanks[5]
Phosphate waste	If $PO_4 > 0.1M$, then do not mix with high-salt ($Na > 8.0M$) waste	$0.047M$ PO_4

Notes:

OH = free hydroxide
TRU = transuranic

[1]Results are from Steen (1996). Average results are used except where less than results were reported; the highest result or less than value was used in these cases.

[2]Fowler (1995)

[3]Liquid samples only

[4]Assumes all $^{239/240}Pu$ is ^{239}Pu and uses a specific activity of 0.0615 Ci/g.

[5]Corrosion limits are only applied to double-contained receiver tanks and DSTs.

2.6 OTHER TECHNICAL ISSUES

2.6.1 Heat Generation

Heat generation and temperature of the waste are factors in assessing tank safety. Heat is generated in the tanks from radioactive decay. The heat load estimate based on the tank process history was 4,800 W (16,400 Btu/hr) (Brevick et al. 1996). The heat load estimate based on the tank headspace temperature was 1,870 W (6,390 Btu/hr) (Kummerer 1995). The heat load estimated from sampling data, presented in Table 2-3, is 2,460 W (8,410 Btu/hr). All these estimates are well below the 11,700 W (40,000 Btu/hr) limit that separates high- and low-heat-load tanks.

Table 2-3. Heat Load Estimate Based on Data from 1996 Core Sample.

Radionuclide	Waste Inventory[1]	Specific Activity[2]	Heat Load
^{90}Sr	51,200 Ci	0.00670 W/Ci	343 W
^{137}Cs	418,000 Ci	0.00472 W/Ci	1,970 W
Total	-	-	2,310 W

Notes:

[1]From Table 3-2.

[2]Includes daughter isotopes.

2.6.2 Pretreatment

Results for the one core composite sample analyzed indicate that approximately 80 percent of the phosphorus, 25 percent of the chromium, and 25 percent of the aluminum is water soluble. As reported in Table 2-1, the aluminum concentration in the sludge is very high (249,000 μg/g).

Although not required in the TCP nor in the *Strategy for Sampling Hanford Site Tank Wastes for Development of Disposal Technology* (Kupfer et al. 1995), a sludge sample from tank 241-S-111 was provided for sludge washing and leaching studies. Sample material from tank 241-S-111 was used because other tanks expected to contain REDOX sludge had not yet been sampled. The sample was a composite of segments 9 through 11 of core 149. Results are not yet available.

2.7 SUMMARY

The results from all analyses performed to address potential safety issues showed that no analyte exceeded safety decision threshold limits. However, only the vapor flammability and toxicity issues have been completely addressed for this tank. The condensed phase issues (criticality, energetics, organic content) cannot be closed because only one of the required two full-length cores were obtained. Again, all analytical results on the one core were well below the action limits.

The historical DQO also required two waste profiles, and thus the requirement has not been met. The testing requirements of the compatibility DQO were met. An assessment of how the sampling data addressed each issue identified for tank 241-S-111 is summarized in Table 2-4.

Table 2-4. Summary of Safety Screening, Organic, Historical, and Compatibility DQO Results.

Issue	Sub-issue	Result
Safety screening	Energetics	Highest upper 95 percent confidence limit for a subsample was 209.5 J/g (action limit is 480 J/g). Only one of the two required cores were recovered.
	Flammable gas	The highest result recorded by the SHMS was 1,270 ppm H_2. This is still well below the H_2 action limit of 6,250 ppm. Results of grab sample data over several months indicates that the hydrogen concentration averaged 72 ppm. Results of vapor sampling and analysis yielded a result near 1 percent of the LFL (action limit is 25 percent of the LFL).
	Criticality	Highest upper 95 percent confidence limit for a subsample was 0.207 μCi/g (action limit was 32.9 μCi/g). Only one of the two required cores was recovered.
Organic	TOC	Highest upper 95 percent confidence limit for a subsample was 12,800 μg C/g (action limit 30,000 μg C/g. Only one of the two required cores were recovered.
	Solvents (total non-methane hydrocarbons in vapor)	Requirement not in place when tank was vapor sampled. A solvent pool of 0.08 m^2 (0.86 ft^2) has been estimated, well below the 1-m^2 (10.8-ft^2) limit.
Compatibility	see Table 2-2	Results are within safety limits. Compatibility assessment not yet performed.
Historical model evaluation	n/a	Because the tank is classified as spatially complex, no specific comparisons are required. Data will be used in statistical comparisons of analytical data and modeling predictions. Only one of the two required cores was recovered. Three distinct layers were observed (supernatant, saltcake, sludge).
Vapor screening	Flammability	Discussed above for safety screening.
	Health effects	All results were below industrial hygiene notification limits.

3.0 BEST-BASIS STANDARD INVENTORY ESTIMATE

Information about the chemical and/or physical properties of tank wastes is used to perform safety analyses, engineering evaluations, and risk assessments associated with waste management activities, as well as to address regulatory issues. Waste management activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing the wastes into a form suitable for long-term storage. Chemical inventory information generally is derived using two approaches: 1) component inventories are estimated using the results of sample analyses; and 2) component inventories are predicted using a model based on process knowledge and historical information. The most recent model was developed by Los Alamos National Laboratory (LANL) (Agnew et al. 1996). Not surprisingly, information derived from these two different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as standard characterization information for the various waste management activities (Kupfer et al. 1995). As part of this effort, an evaluation of available chemical information for tank 241-S-111 was performed that included an evaluation of available chemical information for tank 241-S-111 was performed, including the following:

- The inventory estimate generated by the Hanford defined waste (HDW) model (Agnew et al. 1996)

- An engineering evaluation that produced a predicted concentrated supernatant solids (SMMS1) inventory based on a methodology developed by evaluating tanks 241-S-102, 241-S-102, 241-U-107, and 241-U-109.

- An engineering evaluation of REDOX sludge based on sampling-based data from tank 241-S-102, 241-S-104, and 241-S-107.

- Sample data from tank 241-S-111. Results of sample values are in Appendix B of this document.

Based on this evaluation, a best-basis inventory was developed for tank 241-S-111. For the following reasons, the sample-based evaluation inventory was chosen as the best basis for those analytes for which sampling-based analytical values were available.

- The sampling-based analytical concentrations of the other S and U tanks containing SMMS1 waste compared favorably with 241-S-111 sampling data.

- No methodology is available to fully predict SMMS1 saltcake from process flowsheet or historical records.

- No methodology is available to fully predict REDOX waste generated between 1952 and 1957 (R1) from process flowsheet or historical records for this tank. First-cycle R1 waste changed composition rapidly during the process, and accurate records of these changes are not available at this time. Also, R1 waste was cascaded and transferred into and out of many S, SX, and U tanks between 1972 and 1978, which makes it difficult to predict precipitation factors for analytes in the waste. Some tanks will show higher concentrations for certain analytes because of the length of time the waste was in the tank.

- In several cases, the sampling-based inventories do not support the assumptions and estimates made by the HDW model.

- For those few analytes for tank 241-S-111 where no data were available from the sampling or from the sampling-based inventory of similar tanks, the HDW model values were used with the notation that they were of lower reliability.

The best-basis inventory for tank 241-S-111 is presented in Tables 3-1 and 3-2. The deviation of the best-basis inventory is presented in Appendix D.

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-S-111.

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]	Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]
Al	254,000[2]	S	Ni	101	S
Bi	174	S	NO_2	91,900	S
Ca	497	S	NO_3	707,000	S
Cl	9,000	S	OH	n/r	
Cr	15,100	S	Pb	141	E
F	2,390	S	P as PO_4	25,300	S
Fe	575	S	Si	745	S
Hg	39.7	M	S as SO_4	52,000	S
K	2,330	S	Sr	232	E
La	98	E	TOC	6,600	S
Mn	151	S	U_{TOTAL}	639	S
Na	581,000	S	Zr	15	S

Notes:

n/r = not reported

[1]S = sample-based, M = HDW model-based, E = engineering assessment-based
[2] Based on fusion digest sample results

Table 3-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-S-111.[1]

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[2]	Analyte	Total Inventory (Ci)	Basis (S, M, or E)[2]
^{3}H	n/r		^{226}Ra	n/r	
^{14}C	n/r		^{227}Ac	n/r	
^{59}Ni	n/r		^{228}Ra	n/r	
^{60}Co	n/r		^{229}Th	n/r	
^{63}Ni	n/r		^{231}Pa	n/r	
^{79}Se	n/r		^{232}Th	n/r	
^{90}Sr	51,200	S	^{232}U	n/r	
^{90}Y	51,200	S	^{233}U	n/r	
^{93}Zr	n/r		^{234}U	n/r	
^{93m}Nb	n/r		^{235}U	n/r	
^{99}Tc	n/r		^{236}U	n/r	
^{106}Ru	n/r		^{237}Np	n/r	
^{113m}Cd	n/r		^{238}Pu	n/r	
^{125}Sb	n/r		^{238}U	n/r	
^{126}Sn	n/r		^{239}Pu	264	M
^{129}I	n/r		^{240}Pu	n/r	
^{134}Cs	n/r		^{241}Am	2,530	E
^{137}Cs	418,000	S	^{241}Pu	n/r	
^{137m}Ba	396,000	S	^{242}Cm	n/r	
^{151}Sm	n/r		^{242}Pu	n/r	
^{152}Eu	n/r		^{243}Am	n/r	
^{154}Eu	n/r		^{243}Cm	n/r	
^{155}Eu	n/r		^{244}Cm	n/r	

Notes:

n/r = not reported

[1]Radionuclides decayed to January 1, 1994

[2]S = sample-based, M = HDW model-based, E = engineering assessment-based

4.0 RECOMMENDATIONS

All analytical results for the safety screening, organic, and vapor screening DQOs were well within the safety limits. However, only one of the required two full-length core samples was retrieved, so for these safety-related DQOs, only the vapor screening DQO has been satisfied.

The historical DQO also has not been satisfied, because it, too, requires two profiles of the waste. The data requirements of the compatibility DQO have been met.

Furthermore, sludge samples from the tank have been provided to the Pretreatment Program for use in sludge washing and caustic leaching studies, and a best-basis inventory has been developed for the tank's contents.

Table 4-1 summarizes the status of the Project Hanford Management Contractor (PHMC) Program review and acceptance of the sampling and analysis results reported in this TCR. All DQO issues required to be addressed by sampling and analysis are listed in column one of Table 4-1. The second column indicates whether the requirements of the DQO were met by the sampling and analysis activities performed and is answered with a "Yes" or a "No." The third column indicates concurrence and acceptance by the PHMC program in TWRS that is responsible for the DQO that the sampling and analysis activities performed adequately meet the needs of the DQO. A "yes" or "no" in column three indicates acceptance or disapproval of the sampling and analysis information presented in the TCR.

Table 4-1. Acceptance of Tank 241-S-111 Sampling and Analysis.

Issue	Sampling and Analysis Performed	PHMC Program Acceptance
Safety screening DQO	No[1]	No
Organic DQO	No[1]	No
Vapor screening DQO	Yes	Yes
Historical evaluation DQO	No[1]	No
Compatibility DQO	Yes	Yes

Note:

[1]Sampling not adequate to satisfy these DQOs

Table 4-2 summarizes the status of the PHMC Program review and acceptance of the evaluations and other characterization information contained in this report. The evaluations specifically outlined in this report are the evaluation to determine whether the tank is safe, conditionally safe, or unsafe (safety screening DQO), evaluation of whether organic constituents in the waste are a safety concern (organic DQO), evaluation of the tank's vapors for flammability and potential health effects (vapor screening DQO), and evaluation of the compatibility of the tank's liquids with the DSTs (compatibility DQO). The historical DQO did not require an evaluation of the data for this tank (the data will be used for tank-to-tank statistical comparisons. Column one lists the different evaluations performed in this report. Columns two and three are in the same format as Table 4-1. The manner in which concurrence and acceptance are summarized is also the same as that in Table 4-1. The safety and organic categorization of the tank is listed as "not applicable" in Table 4-2 because sampling was not adequate to fully address these safety issues. However, none of the analyses performed indicate any safety problems.

Another full-length core is required to satisfy the safety screening, organic, and historical DQOs. However, because none of the data from core 149 indicate that a safety concern exists, this second core should not be a high priority relative to sampling other tanks not yet sampled.

Table 4-2. Acceptance of Evaluation of Characterization Data and Information for Tank 241-S-111.

Issue	Evaluation Performed	PHMC Program Acceptance
Safety categorization (tank is safe)	No	Not applicable
Organic complexant assessment (insufficient TOC to cause a concern)	No	Not applicable
Organic solvent screening	Yes	Yes
Vapor assessment (flammability and health impacts within acceptable levels)	Yes	Yes
Compatibility assessment (liquid waste compatible with DSTs)	Not yet	Not applicable
Historical gateway	Not applicable	Not applicable

5.0 REFERENCES

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. Fitzpatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1996, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 3*, LA-UR-96-858, Los Alamos National Laboratory, Los Alamos, New Mexico.

Brevick, C. H., L. A. Gaddis, and W. W. Pickett, 1996, *Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 West Area*, WHC-SD-WM-ER-352, Rev. 0B, Westinghouse Hanford Company, Richland, Washington.

Brown, T. M., S. J. Eberlein, J. W. Hunt, and T. J. Kunthara, 1996, *Tank Waste Characterization Basis*, WHC-SD-WM-TA-164, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

Cash, R. J., 1996, *Scope Increase of 'Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue', Rev. 2*, (internal memorandum 79300-96-029 to S. J. Eberlein, July 12), Westinghouse Hanford Company, Richland, Washington.

Conner, J. M., 1996, *Tank 241-S-111 Push Mode Core Sampling and Analysis Plan*, WHC-SD-WM-TSAP-085, Rev. 0A, Westinghouse Hanford Company, Richland, Washington.

Conner, J. M., and W. D. Winkelman, 1996, *Tank 241-S-111 Tank Characterization Plan*, WHC-SD-WM-TP-317, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

Dukelow, G. T., J. W. Hunt, H. Babad, and J. E. Meacham, 1995, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

Ecology, EPA, and DOE, 1996, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and the U.S. Department of Energy, Olympia, Washington.

Fowler, K. D, 1995, *Data Quality Objectives for the Tank Farms Waste Compatibility Program*, WHC-SD-WM-DQO-001, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Hewitt, E. R., 1996, *Tank Waste Remediation System Resolution of Potentially Hazardous Vapor Issues*, WHC-SD-TWR-RPT-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Homi, C. S., 1995, *Vapor Sampling and Analysis Plan*, WHC-SD-WM-TP-355, Rev. 0G, Westinghouse Hanford Company, Richland, Washington.

Huckaby, J. L., and D. R. Bratzel, 1995, *Tank 241-S-111 Headspace Gas and Vapor Characterization Results for Samples Collected in March 1995*, WHC-SD-WM-ER-507, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Huckaby, J. L., J. A. Glissmeyer, and D. S. Sklarew, 1997, *Screening for Organic Solvents in Hanford Waste Tanks Using Total Non-Methane Organic Compound Vapor Concentrations*, PNNL-11490, Pacific Northwest National Laboratory, Richland, Washington.

Kummerer, M., 1995, *Heat Removal Characteristics of Waste Storage Tanks*, WHC-SD-WM-SARR-010, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Kupfer, M. J., W. W. Schulz, and J. T. Slankas, 1995, *Strategy for Sampling Hanford Site Tank Wastes for Development of Disposal Technology*, WHC-SD-WM-TA-154, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Public Law 101-510, 1990, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation," Section 3137 of *National Defense Authorization Act for Fiscal Year 1991*.

Osborne, J. W., J. L. Huckaby, E. R. Hewitt, C. M. Anderson, D. D. Mahlum, B. A. Pulsipher, and J. Y. Young, 1995, *Data Quality Objectives for Generic In-Tank Health and Safety Vapor Issue Resolution*, WHC-SD-WM-DQO-002, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Osborne, J. W., and L. L. Buckley, 1995, *Data Quality Objectives for Tank Hazardous Vapor Safety Screening*, WHC-SD-WM-DQO-002, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

Simpson, B. C., and D. J. McCain, 1996, *Historical Model Evaluation Data Requirements*, WHC-SD-WM-DQO-018, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Steen, F. H., 1996, *Tank 241-S-111, Cores 149 and 150, Analytical Results for the Final Report*, WHC-SD-WM-DP-195, Rev. 1, Rust Federal Services of Hanford, Inc., Richland, Washington.

Turner, D. A., H. Babad, L. L. Buckley, and J. E. Meacham, 1995, *Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue*, WHC-SD-WM-DQO-006, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

Wilkins, N. E., R. E. Bauer, and D. M. Ogden, 1996, *Results of Vapor Space Monitoring of Flammable Gas Watch List Tanks*, HNF-SD-WM-TI-797, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

This page intentionally left blank.

APPENDIX A

HISTORICAL TANK INFORMATION

This page left blank intentionally.

APPENDIX A

HISTORICAL TANK INFORMATION

Appendix A describes tank 241-S-111 based on historical information. For this report, historical information includes any information about the fill history, waste types, surveillance, or modeling data about the tank. This information is necessary for providing a balanced assessment of the sampling and analytical results.

This appendix contains the following information:

- **Section A1:** Current status of the tank, including the current waste levels as well as the tank's stabilization and isolation status
- **Section A2:** Information about the tank's design
- **Section A3:** Process knowledge of the tank; i.e., the waste transfer history and the estimated contents of the tank based on modeling data
- **Section A4:** Surveillance data for tank 241-S-111, including waste surface-level readings, temperatures, and a description of the waste surface based on photographs
- **Section A5:** Estimate of tank volume and contents
- **Section A6:** References for Appendix A.

Historical sampling results (results from samples obtained prior to 1989) are included in Appendix B.

A1.0 CURRENT TANK STATUS

Tank 241-S-111 contains an estimated 2,040 kL (540 kgal) of waste classified as non-complexed. Liquid waste volume is estimated using core sampling recovery data and photographic evaluation. Solid waste volume is estimated using a combination of surface-level measurements and core sampling recovery data. Estimations of the solid and liquid waste volumes are presented in Section A5.0. The amounts of various waste phases in the tank are presented in Table A1-1.

Table A1-1. Tank Contents Status Summary.

Waste type	kL (kgal)
Total waste	2,040 (540)
Supernatant liquid	87 (23)
Sludge	526 (139)
Saltcake	1,430 (378)
Drainable interstitial liquid	621 (164)
Drainable liquid remaining	653 (172)
Pumpable liquid remaining	427 (113)

Tank 241-S-111 is out of service, as are all single shell tanks, is categorized as sound, and is passively ventilated. The tank is on both the Hydrogen/Flammable Gases and the Organics Watch Lists (Hanlon 1996). All monitoring systems were in compliance with documented standards as of October 31, 1996 (Hanlon 1996).

A2.0 TANK DESIGN AND BACKGROUND

The 241-S Tank Farm was constructed during 1950 and 1951 in the 200 West Area. The farm contains twelve 100-series tanks. The tanks have a nominal capacity of 2,870 kL (758 kgal) and a diameter of 23 m (75 ft) (Leach and Stahl 1993). The 241-S Tank Farm was designed for waste with a maximum fluid temperature of 104 °C (220 °F) (Brevick et al. 1994). A cascade overflow line 75 mm (3 in.) in diameter connects tank 241-S-111 as second in a cascade series of three tanks beginning with tank 241-S-110 and finishing with tank 241-S-112. Each tank in the cascade series is set 0.30 m (1 ft) lower in elevation from the preceding tank. The cascade overflow height is approximately 7.3 m (24 ft) from the tank bottom and 370 mm (1.2 ft) below the top of the steel liner.

The tank has a dished bottom with a 1.2-m (4-ft) radius knuckle. Tank 241-S-111 was designed with a primary mild steel liner (ASTM[1] A283 Grade C) and a concrete dome with various risers. The tank is set on a reinforced concrete foundation. The tank and foundation were waterproofed by a coating of tar covered by a three-ply, asphalt-impregnated waterproofing fabric. The waterproofing was protected by welded wire reinforced with a cement-like mixture. One coat of primer was sprayed on all exposed interior tank surfaces.

[1]American Society for Testing and Materials

The ceiling of the tank dome was covered with six applications of a vinyl resin coating (Rutherford 1949). Lead flashing was used to protect the joint where the steel liner meets the concrete dome. Asbestos gaskets were used to seal the risers in the tank dome.

Tank 241-S-111 has 12 risers, according to the drawings and engineering change notices. The risers range in diameter from 100 mm (4 in.) to 1.1 m (42 in.). Table A2-1 shows numbers, diameters, and descriptions of the risers and the nozzles. A plan view that depicts the riser configuration is shown as Figure A2-1. Risers 11 and 14, 100 mm (4 in.) in diameter, and risers 6, 7, and 8, 300 mm (12 in.) in diameter, are available for use (Lipnicki 1996). A tank cross-section showing the approximate waste level along with a schematic of the tank equipment is in Figure A2-2.

Table A2-1. Tank 241-S-111 Risers.[1,2,3]

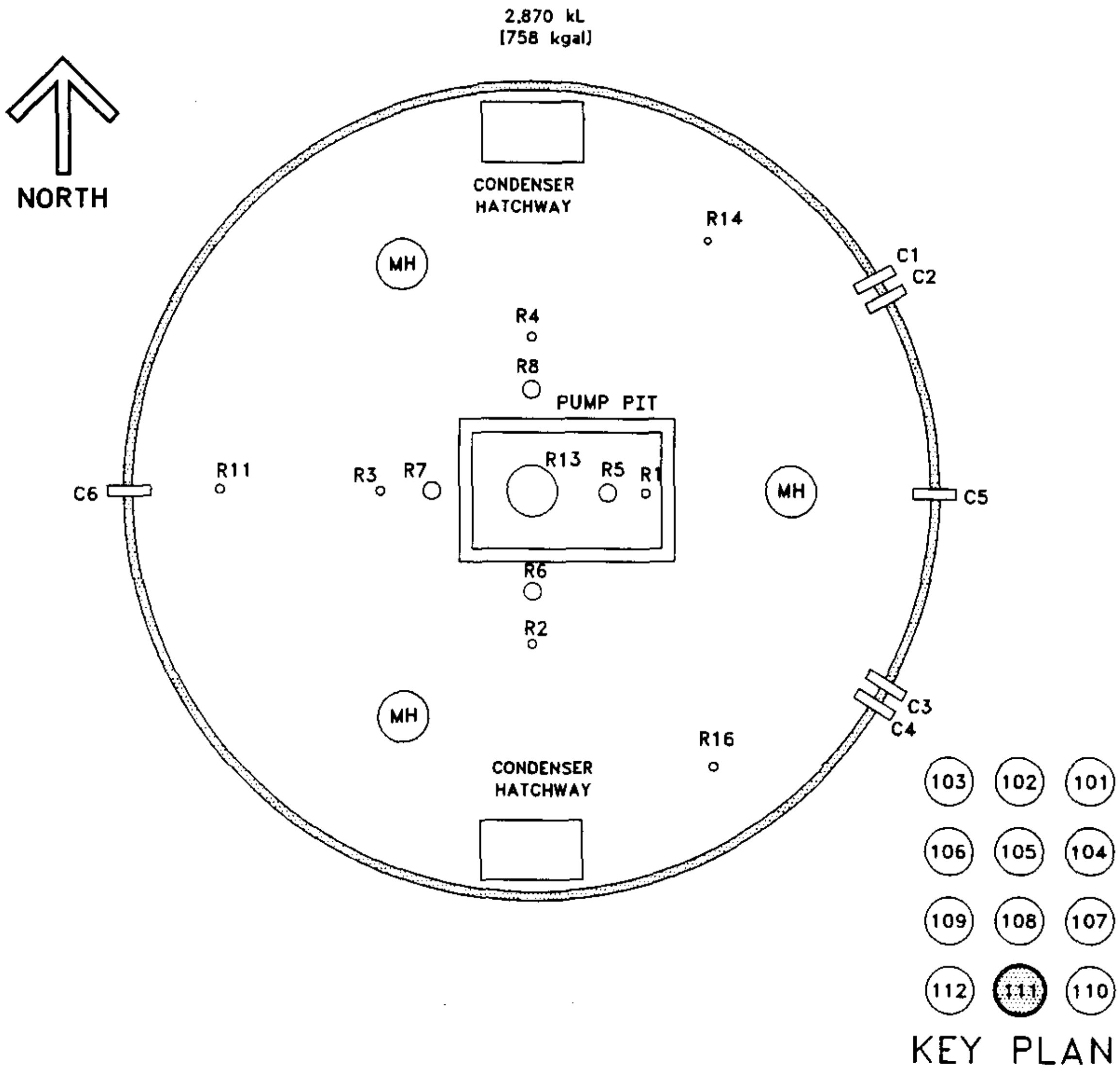
Number	Diameter (in.)	Description and Comments
R1	4	Connector nozzle, pump pit drain
R2	4	Food Instrument Corporation (FIC) level gauge (benchmark)
R3	4	ENRAF[4] (ECN-613546, August 3, 1994)
R4	4	Thermocouple tree
R5	12	Salt well screen and pump
R6	12	Flanged (duct removed, riser capped) (ECN-706501, Aug. 29, 1995)
R7	12	Prototype salt well
R8	12	B-222 observation port
R11	4	Prototype salt well
R13	42	Slurry distributor
R14	4	Hydrogen monitor/breather filter (ECN-W369-11, December 12, 1994)
R16	4	B-436 liquid observation well (benchmark)
C1	3	Spare nozzle, capped
C2	3	Spare nozzle, capped
C3	3	Spare nozzle, capped
C4	3	Spare nozzle, capped
C5	3	Cascade inlet
C6	3	Cascade outlet

Notes:

ECN = engineering change notice

[1]Alstad (1993)
[2]Tran (1993)
[3]Vitro (1988)
[4]Trademark of ENRAF Corporation, Houston, Texas

Figure A2-1. Riser Configuration for Tank 241-S-111.



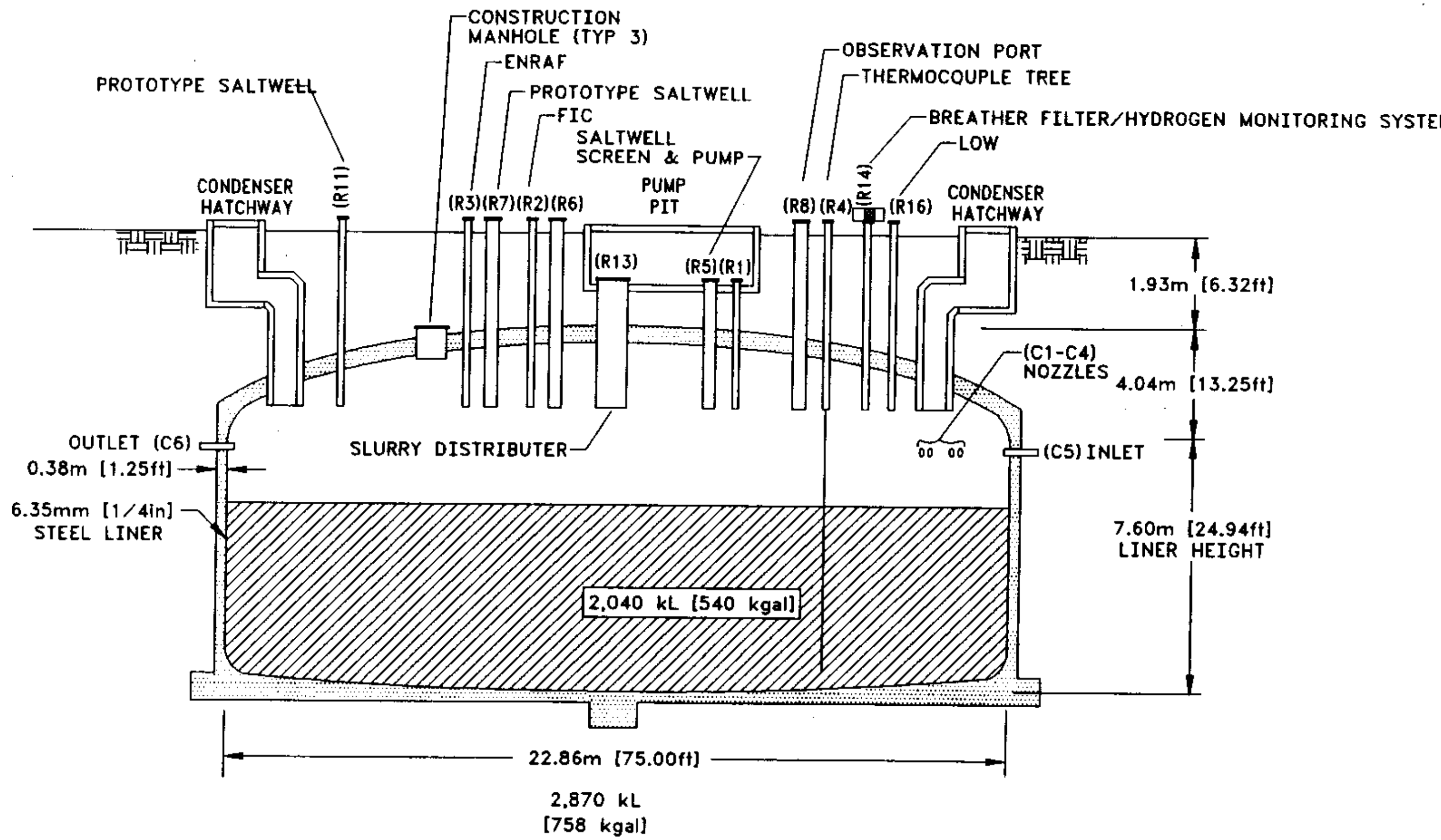


Figure A2-2. Tank 241-S-111 Cross Section and Schematic.

A3.0 PROCESS KNOWLEDGE

The sections below provide information about the waste transfer history of tank 241-S-111, describe the process wastes that were transferred, and give an estimate of the current tank contents based on waste transfer history.

A3.1 WASTE TRANSFER HISTORY

Table A3-1 summarizes the waste transfer history of tank 241-S-111. Tank 241-S-111 first received waste comprised of high-level REDOX (S Plant) waste in the second quarter of 1952 via the cascade line. The tank was full by the third quarter of 1952, and waste then cascaded into tank 241-S-112. From the third quarter of 1953 through the first quarter of 1957, excluding 1956, high-level REDOX waste (R1) and REDOX cladding waste (CWR) was received via the cascade line. The tank was static until the second quarter of 1965, when a small amount of cladding waste was transferred into tank 241-S-111 from tank 241-S-107.

Tank 241-S-111 remained static until the first quarter of 1974, when tank 241-S-111 began sending waste to tank 241-S-102 for use as 242-S Evaporator feed. Tank 241-S-102 returned supernatant from evaporator bottoms waste to tank 241-S-111 during this time. The transfers continued until early 1975, at which time the tank was full. Tank 241-S-111 was removed from service and declared inactive in the second quarter of 1976 (Anderson 1990).

Salt well pumping began in 1976. Dixon (1977) reported that 935 kL (247 kgal) were removed from the tank by salt well pumping. After several problems (equipment failure, work stoppage due to an employee strike, and plugging of the salt well screen), attempts at salt well pumping were apparently halted in 1978. Later transfers described in the waste status and transaction record summary (WSTRS) (Agnew et al. 1996) are incorrect. The tank level data have been static since 1978 (Welty 1988 and LMHC 1997), demonstrating that no further transfers have been made.

Table A3-1. Tank 241-S-111 Major Waste Transfers.[1,2,3]

Transfer Source	Transfer Destination	Waste[4] Type	Time Period	Estimated Waste Volume	
				kL	kgal
241-S-110		R & CWR	1952 - 1955, 1957	6,050	1,600
	241-S-112	R & CWR	1952 - 1955, 1957	-3180	-840
241-S-107		CWR	1965	23	6
	241-S-102	SU	1974 - 1975	-9,585	-2,532
241-S-102		EB, SU	1974 - 1975	9,005	2,379
	unknown	SWLIQ	1976-1978	-935	-247

Notes:

[1]Anderson (1990)

[2]Dixon (1977)

[3]Because only major transfers are listed, the sum of these transfers will not equal the current tank waste volume.

[4]Waste types:

R REDOX high-level waste generated from 1952 to 1966
CWR cladding waste - REDOX
SU supernatant
EB evaporator bottoms
SWLIQ salt well liquid

A3.2 HISTORICAL ESTIMATION OF TANK CONTENTS

The historical transfer data used for this estimate are from the following sources:

- *Waste Status and Transaction Record Summary for the Southwest Quadrant* (WSTRS) (Agnew et al. 1996). WSTRS is a tank-by-tank quarterly summary spreadsheet of waste transactions.

- *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4* (Agnew et al. 1997). This document contains the Hanford defined waste (HDW) list, the supernatant mixing model (SMM), and the tank layer model (TLM).

- Historical Tank Content Estimate for the (Northeast, Northwest, Southeast, Southwest) Quadrant of the Hanford 200 (East or West) Area (HTCE). This set of four documents compiles and summarizes much of the process history, design, and technical information regarding the underground waste storage tanks in the 200 Areas.

- Tank Layer Model (TLM). The TLM defines the sludge and saltcake layers in each tank using waste composition and waste transfer information.

- Supernatant Mixing Model (SMM). This is a subroutine within the HDW model that calculates the volume and composition of certain supernatant blends and concentrates.

Using these records, the TLM defines the sludge and saltcake layers in each tank. The SMM uses information from both the WSTRS and the TLM to describe the supernatants and concentrates in each tank. Together the WSTRS, TLM, and SMM determine each tank's inventory estimate. These model predictions are considered estimates that require further evaluation using analytical data.

Based on the TLM and SMM, tank 241-S-111 contains 2,037 kL (538 kgal) of solids waste comprised of a bottom layer of 240 kL (63 kgal) of REDOX high-level waste (R1) beneath a layer of 45 kL (12 kgal) of REDOX cladding waste from 1952 to 1960 (CWR1), followed by 10 kL (3 kgal) of R1 waste. Above the second R1 layer lies a layer of 230 kL (61 kgal) of an unknown waste and a top solids layer of 1,510 kL (399 kgal) of SMMS1 waste. A 38-kL (10-kgal) layer of supernatant (SU) is above the SMMS1. The SMMS1 concentrations were derived from salt slurry generated in the 242-S Evaporator (S1SltCk). Figure A3-1 shows a graphical representation of the estimated waste types and volumes for each tank layer.

The R1 layer is expected to contain, from highest concentration above one weight percent, the following constituents: hydroxide, nitrate, aluminum, nitrite, iron, and sodium. Constituents expected in this layer above a tenth of a weight percent are chromium, carbonate, calcium, nickel, ammonia, and chloride. Radiological activity will be found in this layer because of the quantity of strontium present. The CWR1 layer should contain, from highest concentration above one weight percent, the following constituents: hydroxide, aluminum, sodium, nitrite, uranium, nitrate, and lead. Constituents contained in this layer above a tenth of a weight percent are iron, carbonate, and calcium. The unknown layer has no specific waste constituent designation. No data are presently available on the exact contents of the SU layer. The SMMS1 layer is defined as a tank-dependent percentage of each of the Hanford defined wastes. Table A3-2 and Table A3-3 show estimates of the expected waste constituents and concentrations.

Figure A3-1. Tank Layer Model for Tank 241-S-111.

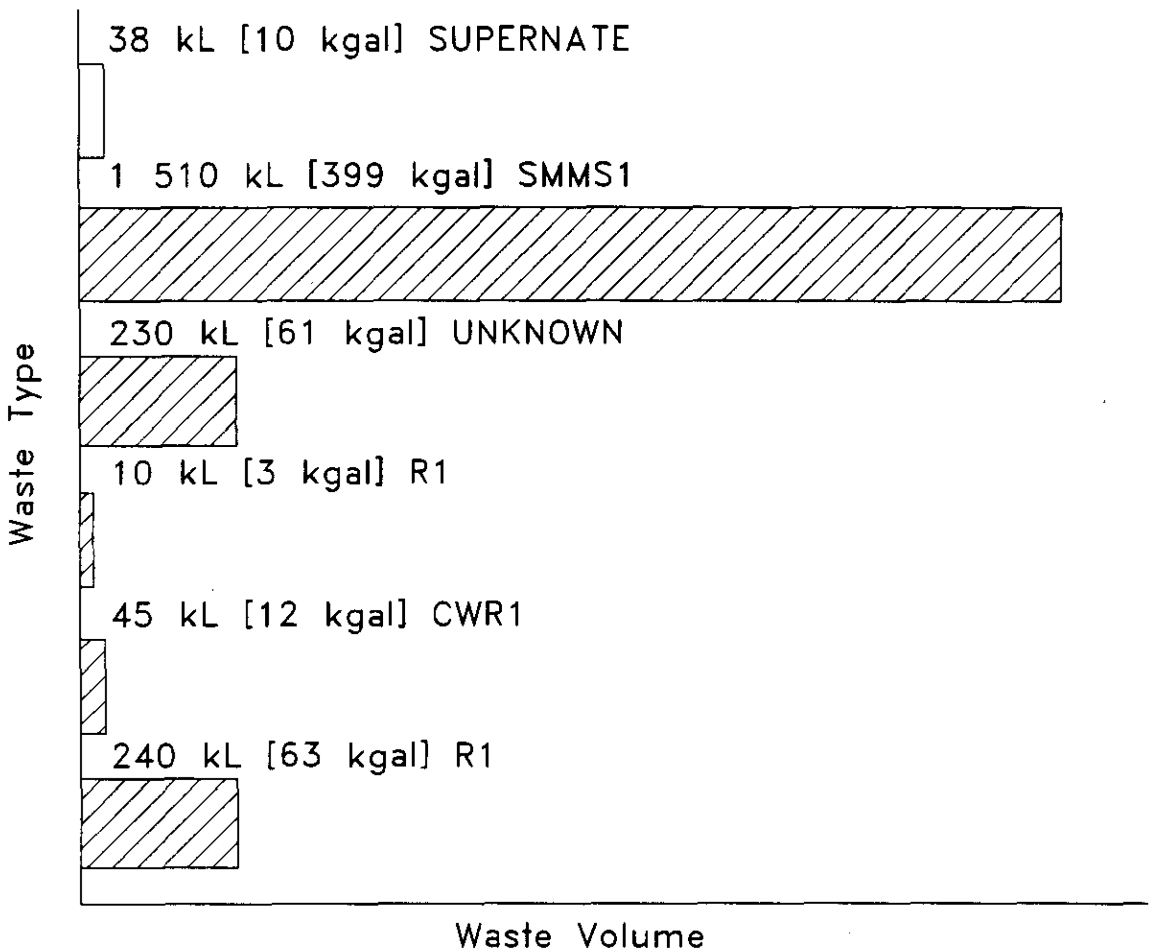


Table A3-2. Historical Tank Inventory Estimate - Analytes.[1,2] (2 sheets)

Total Inventory Estimate							
Physical Properties				-95 CI	-67 CI	+67 CI	+95 CI
Total waste	3.53E+06 (kg) (538 kgal)						
Heat load	5.85 (kW) (2.00E+04 Btu/hr)			5.22	5.57	6.08	6.06
Bulk density	1.73 (g/cm^3)			1.65	1.68	1.79	1.78
Water wt%	26.4			23.7	23.3	29.1	30.8
TOC wt% carbon (wet)	0.429			0.347	0.387	0.470	0.511
Chemical Constituents	*M*	ppm	kg[3]	-95 CI *M*	-67 CI *M*	+67 CI *M*	+95 CI *M*
Na^+	15.6	2.07E+05	7.31E+05	13.9	14.6	16.8	16.5
Al^{3+}	3.01	4.69E+04	1.65E+05	2.82	2.92	3.09	3.10
Fe^{3+} (total Fe)	0.137	4.43E+03	1.56E+04	0.135	0.136	0.138	0.139
Cr^{3+}	0.193	5.79E+03	2.04E+04	0.167	0.181	0.231	0.276
Bi^{3+}	7.70E-04	93.0	328	7.02E-04	7.36E-04	8.05E-04	8.39E-04
La^{3+}	1.37E-05	1.10	3.88	9.95E-06	1.18E-05	1.57E-05	1.75E-05
Hg^{2+}	9.73E-05	11.3	39.8	9.60E-05	9.68E-05	9.77E-05	9.80E-05
Zr (as $ZrO(OH)_2$)	1.46E-04	7.69	27.1	1.33E-04	1.38E-04	1.51E-04	1.58E-04
Pb^{2+}	3.38E-03	405	1.43E+03	3.17E-03	3.30E-03	3.45E-03	3.49E-03
Ni^{2+}	1.21E-02	410	1.44E+03	1.03E-02	1.13E-02	1.27E-02	1.24E-02
Sr^{2+}	0	0	0	0	0	0	0
Mn^{4+}	3.25E-03	103	363	2.36E-03	2.79E-03	3.70E-03	4.13E-03
Ca^{2+}	5.96E-02	1.38E+03	4.87E+03	5.10E-02	5.59E-02	6.28E-02	6.59E-02
K^+	6.37E-02	1.44E+03	5.07E+03	5.83E-02	6.08E-02	6.66E-02	6.94E-02
OH^-	15.7	1.54E+05	5.45E+05	14.5	15.2	16.3	16.3
NO_3^-	5.40	1.93E+05	6.82E+05	4.54	4.71	6.34	6.64
NO_2^-	2.91	7.72E+04	2.72E+05	2.53	2.70	3.10	3.29
CO_3^{2-}	0.353	1.22E+04	4.31E+04	0.322	0.336	0.369	0.379
PO_4^{3-}	6.32E-02	3.47E+03	1.22E+04	5.68E-02	5.90E-02	6.45E-02	6.58E-02
SO_4^{2-}	0.197	1.09E+04	3.85E+04	0.148	0.171	0.223	0.246
Si (as SiO_3^{2-})	7.28E-02	1.18E+03	4.16E+03	6.02E-02	6.64E-02	7.93E-02	8.55E-02
F^-	3.72E-02	409	1.44E+03	3.13E-02	3.38E-02	4.02E-02	4.25E-02
Cl^-	0.251	5.14E+03	1.81E+04	0.230	0.240	0.261	0.270
$C_6H_5O_7^{3-}$	2.49E-02	2.72E+03	9.59E+03	2.31E-02	2.40E-02	2.58E-02	2.67E-02

Table A3-2. Historical Tank Inventory Estimate - Analytes.[1,2] (2 sheets)

Total Inventory Estimate							
Chemical Constituents (Cont'd)	*M*	ppm	kg[3]	-95 CI *M*	-67 CI *M*	+67 CI *M*	+95 CI *M*
$EDTA^{4-}$	5.54E-03	922	3.25E+03	2.07E-03	3.77E-03	7.33E-03	9.07E-03
$HEDTA^{3-}$	9.85E-03	1.56E+03	5.50E+03	2.90E-03	6.30E-03	1.34E-02	1.69E-02
$glycolate^{-}$	5.64E-02	2.45E+03	8.62E+03	3.33E-02	4.46E-02	6.83E-02	7.96E-02
$acetate^{-}$	3.97E-03	135	477	3.26E-03	3.61E-03	4.34E-03	4.69E-03
$oxalate^{2-}$	1.80E-05	0.914	3.22	1.59E-05	1.69E-05	1.90E-05	2.00E-05
DBP	1.62E-02	1.96E+03	6.92E+03	1.31E-02	1.46E-02	1.77E-02	1.92E-02
Butanol	1.62E-02	692	2.44E+03	1.31E-02	1.46E-02	1.77E-02	1.92E-02
NH_3	0.105	1.03E+03	3.64E+03	7.64E-02	8.24E-02	0.116	0.129
$Fe(CN)_6^{4-}$	0	0	0	0	0	0	0

Notes:

CI = confidence interval
DBP = dibutyl phosphate
wt% = weight percent

[1]Agnew et al. (1997)

[2]These predictions have not been validated and should be used with caution.

[3]Differences exist among the inventories in this column and the inventories calculated from the two sets of concentrations.

Table A3-3. Historical Tank Inventory Estimate - Radionuclides.[1,2] (2 sheets)

Total Inventory Estimate							
Physical Properties				-95 CI	-67 CI	+67 CI	+95 CI
Total waste	3.53E+06 (kg) (538 kgal)						
Heat load	5.85 (kW) (2.00E+04 Btu/hr)			5.22	5.57	6.08	6.06
Bulk density	1.73 (g/cm^3)			1.65	1.68	1.79	1.78
Water wt%	26.4			23.7	23.3	29.1	30.8
TOC wt% carbon (wet)	0.429			0.347	0.387	0.470	0.511
Radiological Constituents	Ci/L	µCi/g	Ci	-95 CI (Ci/L)	-67 CI (Ci/L)	+67 CI (Ci/L)	+95 CI (Ci/L)
H-3	2.73E-04	0.158	556	1.60E-04	1.60E-04	2.82E-04	2.82E-04
C-14	3.51E-05	2.03E-02	71.5	1.15E-05	1.15E-05	3.55E-05	3.57E-05
Ni-59	4.06E-06	2.34E-03	8.27	2.95E-06	2.95E-06	4.23E-06	4.17E-06
Ni-63	3.88E-04	0.224	791	2.79E-04	2.79E-04	4.04E-04	3.99E-04
Co-60	3.68E-05	2.12E-02	74.9	9.77E-06	9.77E-06	3.72E-05	3.77E-05
Se-79	3.58E-06	2.07E-03	7.29	2.07E-06	2.07E-06	4.12E-06	4.65E-06
Sr-90	0.226	131	4.60E+05	0.193	0.212	0.237	0.235
Y-90	0.226	131	4.60E+05	0.174	0.174	0.237	0.235
Zr-93	1.75E-05	1.01E-02	35.7	1.00E-05	1.00E-05	2.03E-05	2.29E-05
Nb-93m	1.29E-05	7.43E-03	26.2	7.58E-06	7.58E-06	1.48E-05	1.66E-05
Tc-99	2.51E-04	0.145	511	1.63E-04	2.06E-04	2.96E-04	3.40E-04
Ru-106	6.15E-09	3.55E-06	1.25E-02	2.66E-09	2.66E-09	6.93E-09	7.64E-09
Cd-113m	8.92E-05	5.15E-02	182	4.40E-05	4.40E-05	1.06E-04	1.21E-04
Sb-125	1.53E-04	8.86E-02	313	3.65E-05	3.65E-05	1.55E-04	1.57E-04
Sn-126	5.42E-06	3.13E-03	11.0	3.16E-06	3.16E-06	6.24E-06	7.02E-06
I-129	4.83E-07	2.79E-04	0.984	3.13E-07	3.96E-07	5.71E-07	6.56E-07
Cs-134	1.92E-06	1.11E-03	3.91	1.23E-06	1.23E-06	2.06E-06	2.19E-06
Cs-137	0.289	167	5.88E+05	0.269	0.277	0.299	0.310
Ba-137m	0.273	158	5.56E+05	0.181	0.181	0.281	0.289
Sm-151	1.26E-02	7.29	2.57E+04	7.34E-03	7.34E-03	1.45E-02	1.64E-02
Eu-152	4.24E-06	2.45E-03	8.64	2.38E-06	2.38E-06	4.34E-06	4.43E-06
Eu-154	5.98E-04	0.345	1.22E+03	2.21E-04	2.21E-04	7.34E-04	7.88E-04
Eu-155	2.37E-04	0.137	482	1.25E-04	1.25E-04	2.42E-04	2.48E-04
Ra-226	2.85E-10	1.65E-07	5.80E-04	2.07E-10	2.38E-10	3.25E-10	3.63E-10
Ra-228	7.57E-08	4.37E-05	0.154	3.23E-08	5.35E-08	1.01E-07	1.29E-07
Ac-227	1.51E-09	8.75E-07	3.08E-03	1.14E-09	1.24E-09	1.75E-09	1.97E-09
Pa-231	4.32E-09	2.50E-06	8.81E-03	2.82E-09	2.82E-09	4.87E-09	5.67E-09

Table A3-3. Historical Tank Inventory Estimate - Radionuclides.[1,2] (2 sheets)

Total Inventory Estimate							
Radiological Constituents (Cont'd)	Ci/L	μCi/g	Ci	-95 CI (Ci/L)	-67 CI (Ci/L)	+67 CI (Ci/L)	+95 CI (Ci/L)
Th-229	1.80E-09	1.04E-06	3.66E-03	8.45E-10	1.31E-09	2.36E-09	2.96E-09
Th-232	5.28E-09	3.05E-06	1.08E-02	2.89E-09	4.06E-09	6.51E-09	7.68E-09
U-232	4.27E-07	2.46E-04	0.869	2.53E-07	3.38E-07	5.30E-07	6.39E-07
U-233	1.64E-06	9.45E-04	3.33	9.72E-07	1.30E-06	2.03E-06	2.45E-06
U-234	1.14E-06	6.59E-04	2.32	1.09E-06	1.12E-06	1.16E-06	1.17E-06
U-235	4.73E-08	2.73E-05	9.64E-02	4.52E-08	4.63E-08	4.82E-08	4.84E-08
U-236	3.14E-08	1.82E-05	6.40E-02	3.05E-08	3.10E-08	3.18E-08	3.22E-08
U-238	1.19E-06	6.85E-04	2.42	1.14E-06	1.16E-06	1.21E-06	1.21E-06
Np-237	9.64E-07	5.57E-04	1.96	6.77E-07	8.17E-07	1.11E-06	1.26E-06
Pu-238	2.62E-06	1.51E-03	5.34	2.28E-06	2.45E-06	2.79E-06	2.96E-06
Pu-239	1.38E-04	7.96E-02	281	1.27E-04	1.32E-04	1.43E-04	1.49E-04
Pu-240	2.07E-05	1.20E-02	42.2	1.91E-05	1.99E-05	2.15E-05	2.23E-05
Pu-241	1.63E-04	9.42E-02	332	1.40E-04	1.51E-04	1.75E-04	1.86E-04
Pu-242	8.11E-10	4.68E-07	1.65E-03	6.73E-10	7.41E-10	8.81E-10	9.49E-10
Am-241	5.85E-05	3.38E-02	119	4.25E-05	5.03E-05	6.67E-05	7.45E-05
Am-243	1.84E-09	1.06E-06	3.75E-03	1.34E-09	1.58E-09	2.11E-09	2.36E-09
Cm-242	1.41E-07	8.14E-05	0.287	6.43E-08	6.43E-08	1.45E-07	1.48E-07
Cm-243	1.15E-08	6.65E-06	2.34E-02	4.21E-09	4.21E-09	1.19E-08	1.22E-08
Cm-244	1.19E-07	6.88E-05	0.243	4.38E-08	4.38E-08	1.45E-07	1.61E-07
Total Pu and U Inventory	*M*	μg/g	kg	-95 CI (*M* or g/L)	-67 CI (*M* or g/L)	+67 CI (*M* or g/L)	+95 CI (*M* or g/L)
Pu	2.12E-03 (g/L)	----	4.33	1.94E-03	2.03E-03	2.22E-03	2.31E-03
U	1.35E-02	1.86E+03	6.55E+03	1.29E-02	1.32E-02	1.38E-02	1.38E-02

Notes:

[1]Agnew et al. (1997)

[2]These predictions have not been validated and should be used with caution.

A4.0 SURVEILLANCE DATA

Tank 241-S-111 surveillance includes waste surface level measurements (liquid and solid) and temperature monitoring inside the tank (waste and vapor space). The data provide the basis for determining tank integrity.

Liquid level measurement may indicate if there is a major leak from a tank. Solid surface level measurements provide an indication of physical changes and consistency of the solid layers. Tank 241-S-111 has five drywells, none of which are active. The liquid observation well for tank 241-S-111 is located in riser 16.

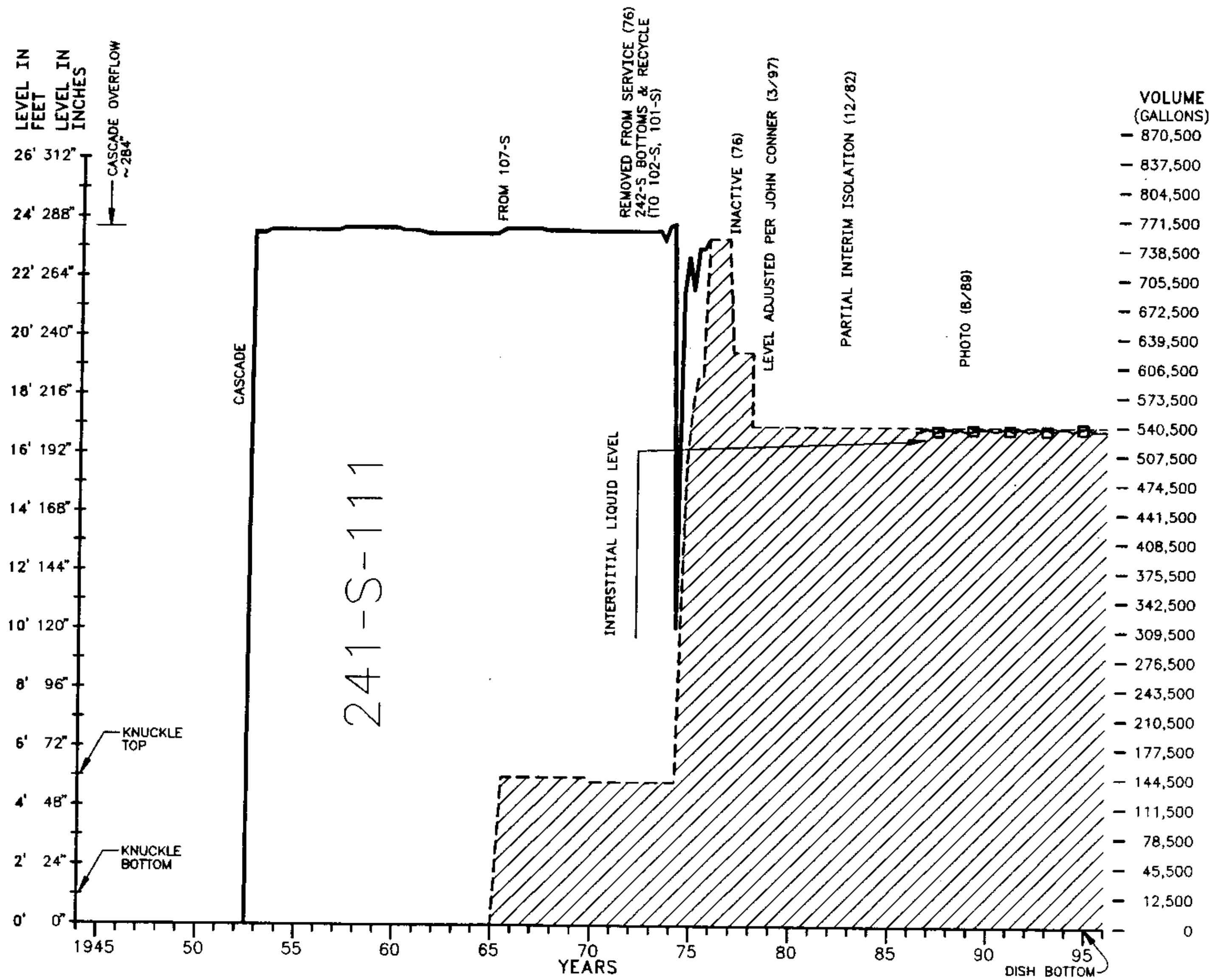
A4.1 SURFACE-LEVEL READINGS

The waste surface level was monitored with a manual tape until June 30, 1981, and with an FIC gauge in the manual and automatic modes until August 8, 1994. The tank is currently monitored with an ENRAF™ gauge (installed December 1995) through riser 3. A surface-level measurement of 5.18 m (203.8 in.) was taken from the automatic ENRAF™ gauge on January 21, 1997 (obtained from the Surveillance Analysis Computer System [SACS]) (LMHC 1997). A review of the SACS data shows a steady surface level since at least January 1981. The neutron interstitial liquid level monitoring data, also obtained from SACS, reported a liquid level of 5.14 m (202.4 in.) on January 15, 1997. These measurements should be virtually identical, because liquid covers a major portion of the tank surface. A graph representing the tank volume history is presented in Figure A4-1.

A4.2 INTERNAL TANK TEMPERATURES

Tank 241-S-111 has a single thermocouple tree, located in riser 4, with 14 thermocouples to monitor the waste temperature. Data are only available for thermocouples 1 through 11 and 13 after September 1996. Elevations are available for all of the thermocouples. Temperature data obtained from SACS (LMHC 1997) were recorded from January 1991 until October 1996. The mean temperature of the SACS data is 28.2 °C (82.7 °F) with a minimum of 18.4 °C (65.2 °F) and a maximum of 36 °C (97 °F). The mean temperature of the SACS data for the last year (October 1995 through October 1996) is 28.5 °C (83.3 °F) with a minimum of 20.4 °C (68.72 °F) and a maximum of 34.9 °C (94.8 °F). On October 13, 1996, the low temperature was 25.9 °C (78.6 °F), recorded on thermocouples 10 and 11, and the maximum was 32.1 °C (89.8 °F), recorded on thermocouples 2, 3, and 4. Thermocouples 2, 3, and 4, with the highest readings, are located in the waste, and thermocouples 10, and 11, with the lowest readings, are located near the waste surface. Plots of the individual thermocouple readings for tank 241-S-111 can be found in Brevick et al. 1994.

Figure A4-1. Tank Level History for Tank 241-S-111.



A4.3 TANK 241-S-111 PHOTOGRAPHS

The August 1989 photographic montage (Brevick et al. 1994) of the tank 241-S-111 interior shows a surface partially covered with solid material, probably saltcake, which appears to be floating on a liquid surface. Approximately the outer 2.4 m (8 feet) is covered with saltcake. A thermocouple tree, level gauge, liquid observation well, salt well screen, risers, and nozzles are visible in the montage. There is a discarded level tape on the surface under riser 14. The waste level in the tank has not changed since the photographs were taken, therefore, the montage should accurately resemble the current appearance of the tank's interior.

A5.0 TANK VOLUME ESTIMATES

The historical waste volume estimate for tank 241-S-111 (Hanlon 1996) is not consistent with the surface level data for the tank. The revised estimates for the volume of the tank, and the volume of the various phases in the tank, are described below. The revised estimates are tabulated in Table A1-1.

A5.1 SURFACE LEVEL AND WASTE VOLUME ESTIMATE

The last transfer of waste from tank 241-S-111 was from salt well pumping in 1978. Liquid level data from Welty (1988) indicates that the waste level stabilized at its current level of approximately 5.15 m (203 in.) in June 1978. The liquid level data, along with FIC and ENRAF™ surface level data (LMHC 1997), have fluctuated within the narrow range of 5.13 to 5.18 m (202 to 204 in.) since that time.

The waste volume of 2,260 kL (596 kgal) given in the tank farms monthly summary (Hanlon 1996) was calculated from a solids volume update in 1982. That estimate was based on a reported FIC surface level measurement of 5.695 m (224.2 in.) (McCann 1982). The only conclusion that can be drawn is that the FIC reading stated in McCann (1982) is erroneous. All FIC and ENRAF™ surface level data, as well as liquid level data dating back to 1978, indicate that the tank surface has remained stable within the range stated above. Based on automatic ENRAF™ data for January 21, 1997 (LMHC 1997), the tank level is 5.18 m (203.8 in.), which indicates a waste volume of 2,040 kL (540 kgal).

A5.2 DRAINABLE LIQUID VOLUME ESTIMATE

Core sampling recovery data (Steen 1996) indicate that the liquid pool in the tank is approximately 86 cm (34 in.) deep under riser 8 (near the middle of the tank).
The August 1989 photographs indicate that most of the tank's surface is liquid, with a band

of saltcake approximately 2.4 m (8 ft) wide around the edge of the tank. If the liquid depth is assumed to vary in a linear fashion from the edge of the saltcake, then the liquid pool would be in the shape of a right cylindrical cone, with a diameter of 18.0 m (59 ft). The volume calculated by the formula $V=\pi d^2h/4$ (Perry and Green 1984), where V is the volume, d is the diameter, and h is the height. The volume of drainable liquid is thus estimated to be 87 kL (23 kgal).

A5.3 ADDITIONAL VOLUME ESTIMATES

Other volume estimates typically provided (Hanlon 1996) include sludge volume, saltcake volume, drainable interstitial liquid volume, and volume of pumpable liquid remaining. Observation of the extruded core samples (Steen 1996) indicates that the sludge layer at the bottom of the tank is approximately 84 cm (33 in.) deep. If this layer is assumed to be flat, this corresponds to a sludge volume estimate of 270 kL (70 kgal). But it is reasonable to expect that the sludge level is not flat accross the tank, and that pumping or sluicing of the sludge would leave a surface that slopes up towards the edge, increasing the volume of sludge left in that tank. Therefore, no strong basis exists for changing the sludge volume stated in Hanlon (1996).

The saltcake volume, however, must be adjusted to account for the new tank volume and supernatant volume estimates. This new estimate for saltcake is 1,430 kL (378 kgal). The reported volumes of drainable interstitial liquid, drainable liquid, and pumpable liquid remaining also must be adjusted. These were simply adjusted downward by the ratio of the current saltcake volume estimate (1,430 kL) to the previous saltcake volume estimate (1,690 kL). That ratio is 0.84. These estimates should be used with caution. All of these volume estimates are presented in Table A1-1.

A6.0 APPENDIX A REFERENCES

Agnew, S. F., P. Baca, R. A. Corbin, T. B. Duran, and K. A. Jurgensen, 1996, *Waste Status and Transaction Record Summary for the Southwest Quadrant*, WHC-SD-WM-TI-614, Rev. 1, Los Alamos National Laboratory, Los Alamos, New Mexico.

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. Fitzpatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1997, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4*, LA-UR-96-3860, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

Alstad, A. T., 1993, *Riser Configuration Document for Single-Shell Waste Tanks*, WHC-SD-RE-TI-053, Rev. 9, Westinghouse Hanford Company, Richland, Washington.

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

Brevick, C. H., L. A. Gaddis, and A. C. Walsh, 1994, *Supporting Document for the Historical Tank Content Estimate for S Tank Farm*, WHC-SD-WM-ER-323, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Dixon, D. R., 1977, *Evaluation of the 241-S-111 Salt Well Jet Pump Prototype*, RHO-CD-80, Rockwell Hanford Company, Richland, Washington.

Hanlon, B. M., 1996, *Waste Tank Summary Report for Month Ending October 31, 1996*, WHC-EP-0182-103, Lockheed Martin Hanford Corporation, Richland, Washington.

Leach, C. E., and S. M. Stahl, 1993, *Hanford Site Tank Farm Facilities Interim Safety Basis*, WHC-SD-WM-ISB-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Lipnicki, J., 1996, *Waste Tank Risers Available for Sampling*, WHC-SD-WM-TI-710, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

LMHC, 1997, Surveillance Analysis Computer System database, January 21, Tank Farm Surveillance Engineering, Lockheed Martin Hanford Corporation, Richland, Washington.

McCann, D. C., 1982, *Waste Status Summary*, RHO-RE-SR-14, Rockwell Hanford Company, Richland, Washington.

Perry, Robert H., and Don Green, 1984, *Perry's Chemical Engineer's Handbook*, 6th Ed., McGraw Hill Book Company, New York, New York.

Rutherford, M. J., 1949, *Specifications for Construction of Waste Disposal Facilities, 241-S, 216-S, 207-S, 200 West Area, Hanford Works*, Specification No. HW3937, General Electric Company, Richland, Washington.

Steen, F. H., 1996, *Tank 241-S-111, Cores 149 and 150, Analytical Results for the Final Report*, WHC-SD-WM-DP-195, Rev. 1, Rust Federal Services of Hanford, Inc., Richland, Washington.

Tran, T. T., 1993, *Thermocouple Status Single Shell & Double Shell Waste Tanks*, WHC-SD-WM-TI-553, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Vitro Engineering Corporation, 1988, *Piping Waste Tank Isolation TK 241-S-111*, Drawing H-2-73190, Rev. 4, Richland, Washington.

Welty, R. K., 1988, *Waste Storage Tank Status and Leak Detection Criteria*, WHC-SD-WM-TI-356, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

This page intentionally left blank.

APPENDIX B

SAMPLING OF TANK 241-S-111

This page intentionally left blank.

APPENDIX B

SAMPLING OF TANK 241-S-111

Appendix B provides sampling and analysis information for each known sampling event for tank 241-S-111, and provides an assessment of the core and vapor sampling results.

- **Section B1**: Tank Sampling Overview
- **Section B2**: 1996 Push-Mode Core Sampling and Analysis
- **Section B3**: Vapor Sampling Results
- **Section B4**: Historical Sampling Results
- **Section B5**: References for Appendix B

Results of any future sampling of tank 241-S-111 will be appended.

B1.0 TANK SAMPLING OVERVIEW

This Appendix describes the sampling events for tank 241-S-111. Emphasis is given to the May-June 1996 push-mode core sampling event. Core sampling was conducted to address the requirements of the *Tank Safety Screening Data Quality Objective* (Dukelow et al. 1995), the *Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue* (Turner et al. 1995), the *Historical Model Data Evaluation Data Requirements* (Simpson and McCain 1995), and the *Data Quality Objectives for Tank Farms Waste Compatibility Program* (Fowler 1995). The sampling and analyses were directed by the *Tank 241-S-111 Push Mode Core Sampling and Analysis Plan* (Conner 1996). In addition, sample material was provided to the Pretreatment program for sludge washing and leaching studies. Discussions of the sampling and analysis procedures can be found in the *Tank Characterization Reference Guide* (De Lorenzo et al. 1994).

Vapor sampling was conducted with a heated vapor probe on March 21, 1995 to address the requirements of the *Data Quality Objectives for Generic In-Tank Health and Safety Vapor Issue Resolution* (Osborne et al. 1995). In addition, vapor grab samples were taken in July and August 1995. A standard hydrogen monitoring system (SHMS) was installed to monitor the hydrogen concentration of the headspace.

Earlier core and liquid sampling events (1980, 1978, 1976, 1974, and 1971) are also noted and discussed.

B2.0 1996 PUSH-MODE CORE SAMPLING EVENT

B2.1 DESCRIPTION OF SAMPLING EVENT

Two push-mode core samples were attempted in 1996. Core 149 was successfully sampled from riser 6. Core 150, from riser 14, was unsuccessful because the waste could not be penetrated (the downforce limit was reached at segment 3). Only 2 of the expected 11 segments were successfully obtained.

The 11 segments from core 149, plus a field blank, were sampled between May 15 and 21, and extruded between May 28 and June 5, 1996. The 7 samples from core 150 (segments 1 and 2, plus 5 attempts at segment 3), were sampled between June 14 and June 19, and extruded between July 16 and July 18. All samples were extruded and analyzed at the 222-S Laboratory. Because sampling was unsuccessful, all of the core 150 samples were archived.

Sampling and analytical requirements from the safety screening, organic, historical, and compatibility DQOs are summarized in Table B2-1.

B2.2 SAMPLE HANDLING

Core 149, recovered from riser 8, consisted of 11 segments. Segments 1 and 2 were Drainable liquid. Segment 3 was mostly Drainable liquid, with a very small solid fraction. Segments 4-9 consisted of solids, and were subsampled into half-segments. Segments 10 and 11 consisted of solids, but were not subsampled into half-segments, as full recovery was not achieved for segment 10, and segment 11 was halted 15 cm (6 in.) into the stroke when the hydraulic bottom detector activated.

Core 150, attempted in riser 14, consisted of 7 samples. Segment 1 consisted of a small amount of solids and liquids. Segment 2 consisted of a full segment of solids, which was subsampled into half segments. Segments 3, 3A, 3B, and 3C contained some solids, liquids, and Liner liquid. Segment 3D was empty. The core was abandoned as drilling forces had reached the allowable downforce pressure (4,000 pounds). Table B2-2 gives the subsampling scheme and sample description.

Table B2-1. Integrated Data Quality Objective Requirements for Tank 241-S-111.

Sampling Event	Applicable DQOs	Sampling Requirements	Analytical Requirements
Core sampling	Safety screening	If inadequate information exists, two cores (full length profiles) required	Energetics, moisture content, total alpha
	Historical model	A minimum of two cores. Widely spaced risers (e.g. side-center)	Energetics, moisture content, organic carbon, metals, anions, radionuclides
	Organic salts	If inadequate information exists, two cores required, preferably from different areas of the tank (e.g. opposite sides or side-center)	Energetics, moisture content, organic carbon
	Compatibility	For routine streams, a single representative sample, along with historical data More than one sample usually required for non-routine transfers	Energetics, moisture content, organic carbon, inorganic carbon, metals, anions, radionuclides
Vapor sampling (heated vapor probe)	Vapor screening	Measurement in at least one location within tank headspace.	Flammable and toxic vapors and gases
	Safety screening	Measurement in at least one location within tank headspace.	Flammable gases
	Organic DQO (amended)	Measurement in at least one location within tank headspace.	Total non-methane hydrocarbons
SHMS	Safety screening	Measurement in at least one location within tank headspace.	Hydrogen

Table B2-2. Tank 241-S-111 Subsampling Scheme and Sample Description.[1] (2 sheets)

Segment	Sample Recovery (%)[2]	Sample Portion	Weight (g)	Sample Characteristics
Core 149, Riser 8				
Field blank	100	Drainable liquid	253.4	Clear, colorless liquid
1	> 100	Drainable liquid	342.7	Partial segment: 13 cm (5 in). Sample was yellow, clear liquid. More than 100 percent recovery was reported - the suction created as the sampler was fully extended caused additional liquid to enter the sampler.
2	100	Drainable liquid	425.7	Yellow, clear liquid
3	100	Drainable liquid	411.1	Dark gray, opaque
		Whole	13.8	Dark gray, resembled salt slurry
4	95	Upper half	188.9	Dark gray solids, resembled wet sludge
		Lower half	176.4	
5	95	Upper half	192.3	Dark gray solids, resembled wet salt
		Lower half	205.2	
6	100	Upper half	240.3	Blue/gray solids, resembled wet salt
		Lower half	250.4	
7	89	Upper half	204.5	Blue/gray solids, resembled moist salt
		Lower half	248.1	
8	100	Upper half	209.7	
		Lower half	235.7	
9	95	Upper half	328.0	Dark blue/gray solids, resembled moist salt
		Lower half	82.6	Light gray, resembled moist salt
10	68	Whole	376.2	Light gray/green solids, resembled wet salt

Table B2-2. Tank 241-S-111 Subsampling Scheme and Sample Description.[1] (2 sheets)

Segment	Sample Recovery (%)[2]	Sample Portion	Weight (g)	Sample Characteristics
Core 149, Riser 8				
11	>100	Whole	244.0	The hydraulic bottom detector halted sampling only 15 cm (6 in.) into the segment. More than 100 percent recovery was reported - the suction created as the sampler was fully extended caused additional material to enter the sampler. Sample was light gray solids, resembled moist salt.
Core 150, Riser 14				
1	73	Drainable liquid	26.0	Partial segment: 10 cm (4 in). Liquid was brown-green, opaque
		Whole solids	18.5	Dark gray, resembled moist salt
2	100	Upper half	190.7	Gray-green, resembled wet salt
		Lower half	179.5	
3	97	Drainable liquid	75.3	Partial segment: 22 cm (8.5 in). Liquid was green, opaque.
		Whole solids	114.6	White and dark gray, resembled salt slurry
3A	100	Liner liquid	119.0	Partial segment: 2.5 cm (1 in.) Liner liquid was yellow and opaque.
		Drainable liquid	73.3	Green, opaque liquid. Small amount of white salt slurry included
3B	100	Liner liquid	116.0	Partial segment: 3.8 cm (1.5 in). Liner liquid was light brown, opaque
		Drainable liquid	26.7	Greenish-yellow, opaque
		Whole solids	13.0	Light to dark gray, resembled salt slurry
3C	100	Liner liquid	99.0	Partial segment: 5 cm (2 in). Liner liquid was light yellow, opaque.
		Whole solids	23.9	Gray-green, resembled moist salt
3D	0	No sample	0.0	Sampler did not advance; sampler empty

Notes:

[1]Steen (1996)

[2]Sample recovery determined from x-ray radiography or extrusion data and density data.

B2.3 SAMPLE ANALYSIS

Because of inadequate recovery (only two of 11 the expected segments were recovered), the core 150 samples were not analyzed. The analyses performed on the core 149 samples were those required by the safety screening, organic, historical, and compatibility DQOs. The analyses required by the safety screening DQO included analyses for thermal properties by differential scanning calorimetry (DSC), moisture content by thermogravimetric analysis (TGA), and fissile material content by total alpha activity analysis. The analyses required by the organic DQO were DSC, TGA, and TOC to determine the organic fuel potential. In addition, all samples were visually inspected for a separable organic phase. Analyses required by the historical DQO included DSC, TGA, and a full set of analytes to be analyzed by ion chromatography (IC), inductively coupled plasma spectroscopy (ICP), and gamma energy analysis (GEA). Additional analyses (total uranium, total beta activity, ^{90}Sr, ICP-water digest, TOC, density, and total alpha activity) were required on core composite samples. Analyses required by the compatibility DQO included DSC, TGA, TOC, GEA, ^{90}Sr, ICP, free hydroxide (OH), IC, hydrogen potential (pH), total inorganic carbon (TIC), $^{239/240}Pu$, ^{241}Am, specific gravity (SpG), percent solids, and separable organics. In addition, ammonia was analyzed on the liquids to help assess the conservatism of the ammonia concentration used in safety assessments (Conner 1996).

All analyses were performed in accordance with approved laboratory procedures. A list of the sample numbers and applicable analyses is presented in Table B2-3. The 222-S Laboratory procedure numbers are presented in Table B2-4.

Table B2-3. Tank 241-S-111 Sample Analysis Summary. (5 sheets)

Segment	Sample Portion	Sample Number	Analyses
		Core 149, Riser 8	
Field blank	liquid	S96T003363	DSC, TGA, total alpha, TIC/TOC, IC, ICP, SpG
1	Drainable liquid	S96T003360	DSC, TGA, total alpha, TIC/TOC, IC, ICP, SpG
		S96T003695	GEA, ^{90}Sr, OH, pH, NH_3, ^{241}Am, $^{239/240}Pu$
2	Drainable liquid	S96T003361	DSC, TGA, total alpha, TIC/TOC, ICP, SpG
		S96T003696	GEA, ^{90}Sr, pH, ^{241}Am, $^{239/240}Pu$
		S96T005969	OH, NH_3, IC

Table B2-3. Tank 241-S-111 Sample Analysis Summary. (5 sheets)

Segment	Sample Portion	Sample Number	Analyses
Core 149, Riser 8 (Cont'd)			
3	Drainable liquid	S96T003362	DSC, TGA, total alpha, TIC/TOC, IC, ICP, SpG
		S96T003697	GEA, ^{90}Sr, OH, pH, NH_3, ^{241}Am, $^{239/240}$Pu
	Whole	S96T003346	Direct: DSC, TGA, TIC/TOC
		S96T003398	Fusion: Total Alpha, GEA
		S96T003420	Acid: ICP
		S96T003421	Water: IC
4	Upper half	S96T003347	Direct: DSC, TGA, TIC/TOC
		S96T003414	Fusion: GEA
		S96T003422	Acid: ICP
		S96T003435	Water: IC
	Lower half	S96T003348	Direct: DSC, TGA, TIC/TOC
		S96T003316	Direct: Bulk density
		S96T003407	Fusion: Total alpha, GEA
		S96T003423	Acid: ICP
		S96T003436	Water: IC
5	Upper half	S96T003349	Direct: DSC, TGA, TIC/TOC
		S96T003415	Fusion: GEA
		S96T003424	Acid: ICP
		S96T003437	Water: IC
	Lower half	S96T003350	Direct: DSC, TGA, TIC/TOC
		S96T003322	Direct: Bulk density
		S96T003408	Fusion: Total alpha, GEA
		S96T003425	Acid: ICP
		S96T003438	Water: IC
6	Upper half	S96T003351	Direct: DSC, TGA, TIC/TOC
		S96T003416	Fusion: GEA
		S96T003426	Acid: ICP
		S96T003439	Water: IC

Table B2-3. Tank 241-S-111 Sample Analysis Summary. (5 sheets)

Segment	Sample Portion	Sample Number	Analyses
Core 149, Riser 8 (Cont'd)			
6 (Cont'd)	Lower half	S96T003352	Direct: DSC, TGA, TIC/TOC
		S96T003323	Direct: Bulk density
		S96T003409	Fusion: Total alpha, GEA
		S96T003427	Acid: ICP
		S96T003440	Water: IC
7	Upper half	S96T003353	Direct: DSC, TGA, TIC/TOC
		S96T003417	Fusion: GEA
		S96T003428	Acid: ICP
		S96T003441	Water: IC
	Lower half	S96T003354	Direct: DSC, TGA, TIC/TOC
		S96T003324	Direct: Bulk density
		S96T003410	Fusion: Total alpha, GEA
		S96T003429	Acid: ICP
		S96T003442	Water: IC
8	Upper half	S96T003355	Direct: DSC, TGA, TIC/TOC
		S96T003418	Fusion: GEA
		S96T003430	Acid: ICP
		S96T003443	Water: IC
	Lower half	S96T003356	Direct: DSC, TGA, TIC/TOC
		S96T003325	Direct: Bulk density
		S96T003411	Fusion: Total alpha, GEA
		S96T003431	Acid: ICP
		S96T003444	Water: IC
9	Upper half	S96T003357	Direct: DSC, TGA, TIC/TOC
		S96T003419	Fusion: GEA, ICP
		S96T003432	Acid: ICP
		S96T003445	Water: IC

Table B2-3. Tank 241-S-111 Sample Analysis Summary. (5 sheets)

Segment	Sample Portion	Sample Number	Analyses
Core 149, Riser 8 (Cont'd)			
9 (Cont'd)	Lower half	S96T003358	Direct: DSC, TGA, TIC/TOC
		S96T003344	Direct: Bulk density
		S96T003412	Fusion: Total alpha, GEA, ICP
		S96T003433	Acid: ICP
		S96T003446	Water: IC
10	Upper half	S96T003617	Direct: DSC, TGA, TIC/TOC
		S96T003613	Direct: Bulk density
		S96T003619	Fusion: Total alpha, GEA, ICP
		S96T003620	Acid: ICP
		S96T003621	Water: IC
11	Upper half	S96T003359	Direct: DSC, TGA, TIC/TOC
		S96T003345	Direct: Bulk density
		S96T003413	Fusion: Total alpha, GEA, ICP
		S96T003434	Acid: ICP
		S96T003447	Water: IC
Core composite	Core composite (solids)	S96T004757	Direct: DSC, TGA, TIC/TOC
		S96T004755	Direct: Bulk density
		S96T004758	Fusion: Total alpha, GEA, total beta, ^{90}Sr, Total U, ICP
		S96T004759	Acid: ICP
		S96T004760	Water: IC
		S96T004761	Water: ICP
Core 150, Riser 14			
Hydrostatic head fluid sample	liquid	S96T003667	IC, ICP
1	Drainable liquid	S96T004182	Not analyzed
	Whole solids	S96T004189	Not analyzed
2	Upper half	S96T004195	Not analyzed
	Lower half	S96T004196	Not analyzed

Table B2-3. Tank 241-S-111 Sample Analysis Summary. (5 sheets)

Segment	Sample Portion	Sample Number	Analyses
Core 150, Riser 14 (Cont'd)			
3	Drainable liquid	S96T004183	Not analyzed
	Whole solids	S96T004192	Not analyzed
3A	Liner liquid	S96T004185	Not analyzed
	Drainable liquid	S96T004184	Not analyzed
3B	Liner liquid	S96T004186	Not analyzed
	Drainable liquid	S96T004187	Not analyzed
	Whole solids	S96T004193	Not analyzed
3C	Liner liquid	S96T004188	Not analyzed
	Whole solids	S96T004194	Not analyzed
3D	No sample	n/a	Not analyzed

Note:
n/a = not applicable

Table B2-4. Preparatory and Analytical Procedures.

Analysis	Matrix	Preparation Procedure	Analysis Procedure
DSC	Solid/ Liquid	n/a[1]	LA-514-114 LA-514-113
TGA	Solid/ Liquid	n/a[1]	LA-514-114 LA-560-112
Bulk density	Solid	n/a[1]	LO-160-103
Specific gravity	Liquid	n/a[1]	LA-510-112
NH3	Liquid	n/a[1]	LA-631-001
IC	Solid	LA-504-101 (water digest)	LA-533-105
	Liquid	n/a[1]	
ICP	Solid	LA-549-141 (fusion digest) LA-505-159 (acid digest) LA-505-163 (acid digest) LA-504-101 (water digest)	LA-505-151 LA-505-161
	Liquid	n/a[1]	
OH-	Liquid	n/a[1]	LA-211-102
pH	Liquid	n/a[1]	LA-212-106
TIC/TOC	Solid	n/a[1]	LA-342-100
U total	Solid	LA-549-141 (fusion)	LA-943-128
Total alpha/ total beta	Solid	LA-549-141 (fusion)	LA-508-101
	Liquid	n/a[1]	
GEA	Solid	LA-549-141 (fusion)	LA-548-121
	Liquid	n/a[1]	
^{241}Am	Liquid	n/a[1]	LA-953-103
^{90}Sr	Solid	LA-549-141 (fusion)	LA-220-101
	Liquid	n/a[1]	
$^{239/240}$Pu	Liquid	n/a[1]	LA-943-128

Note:

[1]Direct samples - no preparation required

B2.4 CORE SAMPLING ANALYTICAL RESULTS

This section summarizes the sampling and analytical results associated with the May-June 1996 sampling and analysis of tank 241-S-111. Table B2-5 shows where analytical data from this sampling and analysis event are tabulated in this report. All analytical results are taken from Steen (1996).

Table B2-5. Analytical Presentation Tables.

Analysis	Table Number
Total alpha activity	B2-6
Total beta activity	B2-7
Strontium-90	B2-8
Radionuclides by GEA	B2-9 through B2-13
Plutonium 239/240	B2-14
Americium-241	B2-15
Energetics (DSC)	B2-16
Moisture (TGA)	B2-17
Anions by IC	B2-18 through B2-25
Cations by ICP	B2-26 through B2-62
Total uranium	B2-63
Free hydroxide (OH)	B2-64
Hydrogen potential (pH)	B2-65
Ammonia	B2-66
Total inorganic carbon	B2-67
Total organic carbon	B2-68
Bulk density	B2-69
Specific gravity	B2-70

The four quality control (QC) parameters assessed in conjunction with the tank 241-S-111 samples were standard recoveries, spike recoveries, duplicate analyses, and blanks. The QC criteria specified in the sampling and analysis plan (SAP) (Conner 1996) are as follows: relative percent difference (RPD) between sample and duplicate < 20 percent, except for DSC and TGA on solids (RPD < 30 percent); spike recovery from 75 to 125 percent; standard recovery from 80 to 120 percent, except for total beta (80 to 110 percent), ^{90}Sr (75 to 125 percent), and total alpha (70 to 130 percent); preparation blanks less than the estimated quantitation limit or minimum detectable activity, as appropriate. No QC parameters were required on bulk density, SpG, or TIC.

Samples for which any of the QC parameters were outside of these limits are footnoted in the sample mean column of the following summary tables with an a, b, c, d, or e as follows:

- "a" indicates that the standard recovery was below the QC limit.
- "b" indicates that the standard recovery was above the QC limit.
- "c" indicates that the spike recovery was below the QC limit.
- "d" indicates that the spike recovery was above the QC limit.
- "e" indicates that the RPD was above the QC limit.
- "f" indicates that there was blank contamination.

B2.4.1 Radiochemical Analyses

B2.4.1.1 Total Alpha Activity. Total alpha activity measurements were performed on samples that had been fused in a solution of potassium hydroxide and then dissolved in acid (liquid samples were simply diluted). The resulting solution was then dried on a counting planchet and counted in an alpha proportional counter. Two fusions were prepared per sample (for duplicate results). Each fused dilution was analyzed twice, and the results were averaged and reported as one value. The sample results for total alpha are given in Table B2-6. Quality control tests consisted included standard, spike, blank, and duplicate analyses.

Table B2-6. Tank 241-S-111 Analytical Results: Total Alpha.

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µCi/mL	µCi/mL	µCi/mL
S96T003360	149: 1	Drainable liquid	< 0.00858	< 0.0052	< 0.00689
S96T003361	149: 2	Drainable liquid	< 0.00691	< 0.00691	< 0.00691
S96T003362	149: 3	Drainable liquid	< 0.00858	< 0.0119	< 0.01024
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003398	149: 3	Whole	0.0314	0.0278	0.0296
S96T003407	149: 4	Lower half	0.0473	0.0488	0.04805
S96T003408	149: 5	Lower half	0.0262	0.0205	0.02335[QC:e]
S96T003409	149: 6	Lower half	0.0265	0.0275	0.027[QC:f]
S96T003410	149: 7	Lower half	0.0203	0.021	0.02065[QC:f]
S96T003411	149: 8	Lower half	0.0272	0.0379	0.03255[QC:e]
S96T003412	149: 9	Lower half	0.0921	0.0489	0.0705[QC:e]
S96T003619	149:10	Upper half	< 0.00321	< 0.00369	< 0.00345
S96T003413	149:11	Upper half	0.00193	0.00177	0.00185[QC:f]
S96T004758	Core 149	Solid composite	0.015	0.0107	0.01285[QC:e]

B2.4.1.2 Total Beta Activity. Total beta activity was measured for the core composite sample on a fusion-digested aliquot that was evaporated to dryness on a planchet and counted. Two fusions were prepared per sample (for duplicate results). Each fused dilution was analyzed twice, and the results were averaged and reported as one value. Quality control tests included standard, blank, spike, and duplicate analyses. Results are presented in Table B2-7.

Table B2-7. Tank 241-S-111 Analytical Results: Total Beta

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T004758	Core 149	Solid composite	142	134	138[QC:b]

B2.4.1.3 Strontium-90. Liquid samples and a fusion-digested subsample from the core composite were analyzed for $^{89/90}$Sr. Strontium was separated from the solution by several precipitation/dissolution steps and counted for beta emissions. Two subsamples were prepared per sample (for duplicate results). Each subsample was analyzed twice, and the results were averaged and reported as one value. The reported result is assumed to be all ^{90}Sr (the contribution of ^{89}Sr will be negligible because its half-life is only 51 days). Quality control tests included standards, blanks, spikes, and duplicate analyses. Results are presented in Table B2-8.

Table B2-8. Tank 241-S-111 Analytical Results: Strontium-89/90 (Sr).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µCi/mL	µCi/mL	µCi/mL
S96T003695	149: 1	Drainable liquid	0.0451	0.0427	0.0439
S96T003696	149: 2	Drainable liquid	0.0461	0.0443	0.0452
S96T003697	149: 3	Drainable liquid	1.22	1.19	1.205
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T004758	Core 149	Solid composite	13.2	14.6	13.9

B2.4.1.4 Gamma Energy Analysis. GEA was performed on solids subsamples following a fusion digestion, and on liquid samples. Solutions were analyzed by gamma counting and energy analysis. Quality control tests included standards, blanks, spikes, and duplicate analyses. Results are reported for ^{241}Am, ^{137}Cs, ^{60}Co, ^{154}Eu, and ^{155}Eu in Tables B2-9 to B2-13.

Table B2-9. Tank 241-S-111 Analytical Results: Americium-241 (GEA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µCi/mL	µCi/mL	µCi/mL
S96T003695	149: 1	Drainable liquid	< 0.381	< 0.787	< 0.584
S96T003696	149: 2	Drainable liquid	< 0.3676	< 0.776	< 0.5718
S96T003697	149: 3	Drainable liquid	< 0.7637	< 0.756	< 0.75985
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003398	149: 3	Whole	< 0.2423	< 0.242	< 0.24215
S96T003414	149: 4	Upper half	< 0.2309	< 0.239	< 0.23495
S96T003407		Lower half	< 0.2348	< 0.228	< 0.2314
S96T003415	149: 5	Upper half	< 1.298	< 1.2	< 1.249
S96T003408		Lower half	< 1.353	< 1.34	< 1.3465
S96T003416	149: 6	Upper half	< 1.41	< 1.38	< 1.395
S96T003409		Lower half	< 0.9456	< 0.967	< 0.9563
S96T003417	149: 7	Upper half	< 1.008	< 1.05	< 1.029
S96T003410		Lower half	< 0.9774	< 0.942	< 0.9597
S96T003418	149: 8	Upper half	< 0.9169	< 0.935	< 0.92595
S96T003411		Lower half	< 1.436	< 1.41	< 1.423
S96T003419	149: 9	Upper half	< 2.59	< 2.81	< 2.7
S96T003412		Lower half	< 1.468	< 1.53	< 1.499
S96T003619	149:10	Upper half	< 0.7943	< 0.808	< 0.80115
S96T003413	149:11	Upper half	< 0.7271	< 0.723	< 0.72505
S96T004758	Core 149	Solid composite	< 0.707	< 0.679	< 0.693

Table B2-10. Tank 241-S-111 Analytical Results: Cesium-137 (GEA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µCi/mL	µCi/mL	µCi/mL
S96T003695	149: 1	Drainable liquid	233	260	246.5
S96T003696	149: 2	Drainable liquid	217	256	236.5
S96T003697	149: 3	Drainable liquid	249	241	245
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003398	149: 3	Whole	147.4	135	141.2
S96T003414	149: 4	Upper half	127.6	133	130.3
S96T003407		Lower half	132.4	131	131.7
S96T003415	149: 5	Upper half	107.4	104	105.7
S96T003408		Lower half	112.7	112	112.35
S96T003416	149: 6	Upper half	113.8	113	113.4
S96T003409		Lower half	109	116	112.5
S96T003417	149: 7	Upper half	119.9	129	124.45
S96T003410		Lower half	111.9	104	107.95
S96T003418	149: 8	Upper half	107.9	106	106.95
S96T003411		Lower half	122.6	108	115.3
S96T003419	149: 9	Upper half	151.7	167	159.35
S96T003412		Lower half	125.2	133	129.1
S96T003619	149:10	Upper half	72.59	72.8	72.695
S96T003413	149:11	Upper half	64.27	61.3	62.785
S96T004758	Core 149	Solid composite	117.3	107	112.15

Table B2-11. Tank 241-S-111 Analytical Results: Cobalt-60 (GEA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µCi/mL	µCi/mL	µCi/mL
S96T003695	149: 1	Drainable liquid	< 0.006353	< 0.00871	< 0.0075315
S96T003696	149: 2	Drainable liquid	< 0.005754	< 0.00657	< 0.006162
S96T003697	149: 3	Drainable liquid	< 0.009224	< 0.0101	< 0.009662
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003398	149: 3	Whole	< 0.0953	< 0.0925	< 0.0939
S96T003414	149: 4	Upper half	< 0.09637	< 0.0856	< 0.090985
S96T003407		Lower half	< 0.1024	< 0.0879	< 0.09515
S96T003415	149: 5	Upper half	< 0.04804	< 0.0443	< 0.04617
S96T003408		Lower half	< 0.05173	< 0.0475	< 0.049615
S96T003416	149: 6	Upper half	< 0.05959	< 0.0515	< 0.055545
S96T003409		Lower half	< 0.02193	< 0.0367	< 0.029315
S96T003417	149: 7	Upper half	< 0.03229	< 0.0294	< 0.030845
S96T003410		Lower half	< 0.02805	< 0.0349	< 0.031475
S96T003418	149: 8	Upper half	< 0.02845	< 0.0364	< 0.032425
S96T003411		Lower half	< 0.05323	< 0.0555	< 0.054365
S96T003419	149: 9	Upper half	< 0.1247	< 0.137	< 0.13085
S96T003412		Lower half	< 0.06034	< 0.0513	< 0.05582
S96T003619	149:10	Upper half	< 0.02705	< 0.035	< 0.031025
S96T003413	149:11	Upper half	< 0.03684	< 0.0328	< 0.03482
S96T004758	Core 149	Solid composite	< 0.01713	< 0.0152	< 0.016165

Table B2-12. Tank 241-S-111 Analytical Results: Europium-154 (GEA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µCi/mL	µCi/mL	µCi/mL
S96T003695	149: 1	Drainable liquid	< 0.04687	< 0.054	< 0.050435
S96T003696	149: 2	Drainable liquid	< 0.04509	< 0.0525	< 0.048795
S96T003697	149: 3	Drainable liquid	< 0.04908	< 0.0489	< 0.04899
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003398	149: 3	Whole	< 0.3035	< 0.271	< 0.28725
S96T003414	149: 4	Upper half	< 0.3109	< 0.331	< 0.32095
S96T003407		Lower half	< 0.2903	< 0.265	< 0.27765
S96T003415	149: 5	Upper half	< 0.1533	< 0.152	< 0.15265
S96T003408		Lower half	< 0.1433	< 0.191	< 0.16715
S96T003416	149: 6	Upper half	< 0.1718	< 0.156	< 0.1639
S96T003409		Lower half	< 0.1033	< 0.127	< 0.11515
S96T003417	149: 7	Upper half	< 0.1335	< 0.105	< 0.11925
S96T003410		Lower half	< 0.1263	< 0.105	< 0.11565
S96T003418	149: 8	Upper half	< 0.09669	< 0.0915	< 0.094095
S96T003411		Lower half	< 0.2248	< 0.176	< 0.2004
S96T003419	149: 9	Upper half	< 0.419	< 0.38	< 0.3995
S96T003412		Lower half	< 0.1952	< 0.161	< 0.1781
S96T003619	149:10	Upper half	< 0.1116	< 0.105	< 0.1083
S96T003413	149:11	Upper half	< 0.07498	< 0.0628	< 0.06889
S96T004758	Core 149	Solid composite	< 0.05888	< 0.059	< 0.05894

Table B2-13. Tank 241-S-111 Analytical Results: Europium-155 (GEA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µCi/mL	µCi/mL	µCi/mL
S96T003695	149: 1	Drainable liquid	< 0.1457	< 0.34	< 0.24285
S96T003696	149: 2	Drainable liquid	< 0.1411	< 0.338	< 0.23955
S96T003697	149: 3	Drainable liquid	< 0.3333	< 0.328	< 0.33065
Solids: fusion			µCi/g	µCi/g	µCi/g
S96T003398	149: 3	Whole	< 0.4567	< 0.447	< 0.45185
S96T003414	149: 4	Upper half	< 0.4352	< 0.435	< 0.4351
S96T003407		Lower half	< 0.436	< 0.432	< 0.434
S96T003415	149: 5	Upper half	< 0.4818	< 0.478	< 0.4799
S96T003408		Lower half	< 0.5071	< 0.508	< 0.50755
S96T003416	149: 6	Upper half	< 0.536	< 0.532	< 0.534
S96T003409		Lower half	< 0.4468	< 0.46	< 0.4534
S96T003417	149: 7	Upper half	< 0.4915	< 0.5	< 0.49575
S96T003410		Lower half	< 0.4748	< 0.459	< 0.4669
S96T003418	149: 8	Upper half	< 0.3508	< 0.357	< 0.3539
S96T003411		Lower half	< 0.5389	< 0.523	< 0.53095
S96T003419	149: 9	Upper half	< 0.9887	< 1.03	< 1.00935
S96T003412		Lower half	< 0.709	< 0.723	< 0.716
S96T003619	149:10	Upper half	< 0.3801	< 0.39	< 0.38505
S96T003413	149:11	Upper half	< 0.3555	< 0.344	< 0.34975
S96T004758	Core 149	Solid composite	< 0.2684	< 0.255	< 0.2617

B2.4.1.5 Plutonium-239/240. $^{239/240}Pu$ was measured on liquid subsamples by TRU extraction and chemical separation of Pu, followed by alpha counting and alpha energy analysis. Quality control tests include standard, blank, spike, and duplicate analyses. Results are presented in Table B2-14.

Table B2-14. Tank 241-S-111 Analytical Results: Plutonium-239/40.

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µCi/mL	µCi/mL	µCi/mL
S96T003695	149: 1	Drainable liquid	< 3.450E-05	< 3.480E-05	< 3.465E-05
S96T003696	149: 2	Drainable liquid	< 1.790E-04	< 1.930E-04	< 1.860E-04
S96T003697	149: 3	Drainable liquid	< 7.280E-05	< 7.620E-05	< 7.450E-05

B2.4.1.6 Americium-241. In addition to the GEA analyses, ^{241}Am was measured on liquid subsamples by TRU extraction and chemical separation of Am/Cm, followed by alpha counting and alpha energy analysis. Quality control tests include standard, blank, spike, and duplicate analyses. Results are presented in Table B2-15.

Table B2-15. Tank 241-S-111 Analytical Results: Americium-241.

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µCi/mL	µCi/mL	µCi/mL
S96T003695	149: 1	Drainable liquid	9.320E-05	1.040E-04	9.860E-05
S96T003696	149: 2	Drainable liquid	< 3.600E-04	< 3.380E-04	< 3.490E-04
S96T003697	149: 3	Drainable liquid	3.190E-04	3.180E-04	3.185E-04

B2.4.2 Thermodynamic Analyses

B2.4.2.1 Differential Scanning Calorimetry. In a DSC analysis, heat absorbed or emitted by a substance is measured while the temperature of the sample is heated at a constant rate. Nitrogen is passed over the sample material to remove any gases being released. The onset temperature for an endothermic or exothermic event is determined graphically. The DSC and TGA tests were performed on homogenized subsamples that ranged from 5.620 to 59.012 mg in weight. Quality control tests included standard and duplicate analyses. Results are presented in Table B2-16.

Table B2-16. Tank 241-S-111 Analytical Results: Exotherm (DSC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			J/g	J/g	J/g
S96T003360	149: 1	Drainable liquid	0	0	0
S96T003361	149: 2	Drainable liquid	0	0	0
S96T003362	149: 3	Drainable liquid	0	0	0
Solids			J/g	J/g	J/g
S96T003346	149: 3	Whole	64.5	74.8	69.65
S96T003347	149: 4	Upper half	43.1	40.6	41.85
S96T003348		Lower half	44.7	41.2	42.95
S96T003349	149: 5	Upper half	0	0	0
S96T003350		Lower half	0	0	0
S96T003351	149: 6	Upper half	34.4	41.1	37.75
S96T003352		Lower half	0	0	0
S96T003353	149: 7	Upper half	53.96	51.17	52.565
S96T003354		Lower half	0	0	0
S96T003355	149: 8	Upper half	0	0	0
S96T003356		Lower half	0	0	0
S96T003357	149: 9	Upper half	12	20.3	16.15[QC:e]
S96T003358		Lower half	0	0	0
S96T003617	149: 10	Upper half	53.96	51.17	52.565
S96T003359	149: 11	Upper half	0	51.17	52.565
S96T004757	Core 149	Solid composite	0	0	0

B2.4.2.2 Thermogravimetric Analysis. Thermogravimetric analysis measures the mass of a sample while its temperature is increased at a constant rate. Nitrogen is passed over the sample during heating to remove any released gases. Any decrease in the weight of a sample during TGA represents a loss of gaseous matter from the sample, either through evaporation or through a reaction that forms gas phase products. The moisture content is estimated by assuming that all TGA sample weight loss up to a certain temperature (typically 150 to 200 °C [300 to 390 °F]) is due to water evaporation. The temperature limit for moisture loss is chosen by the operator at an inflection point on the TGA plot. Other volatile matter fractions can often be differentiated by inflection points as well. The TGA tests were performed on homogenized subsamples that ranged from 5.444 to 72.599 mg in weight. Quality control tests included standard and duplicate analyses. Results are presented in Table B2-17.

Table B2-17. Tank 241-S-111 Analytical Results: Percent Water (DSC/TGA).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			%	%	%
S96T003360	149: 1	Drainable liquid	53.49	53.4	53.445
S96T003361	149: 2	Drainable liquid	53.36	53.22	53.29
S96T003362	149: 3	Drainable liquid	52.9	52.7	52.8
Solids			%	%	%
S96T003346	149: 3	Whole	51.24	50.59	50.915
S96T003347	149: 4	Upper half	43.02	43.02	43.02
S96T003348		Lower half	41.19	35.23	38.21
S96T003349	149: 5	Upper half	26.76	29.4	28.08
S96T003350		Lower half	38.87	34.1	36.485
S96T003351	149: 6	Upper half	26.7	26.7	26.7
S96T003352		Lower half	29.48	29.41	29.445
S96T003353	149: 7	Upper half	27.89	27.03	27.46
S96T003354		Lower half	22.7	20.61	21.655
S96T003355	149: 8	Upper half	23.05	22.73	22.89
S96T003356		Lower half	22.45	27.67	25.06
S96T003357	149: 9	Upper half	30.11	29.69	29.9
S96T003358		Lower half	37.55	34.54	36.045
S96T003617	149:10	Upper half	11.82	11.42	11.62
S96T003359	149:11	Upper half	10.25	10.91	10.58
S96T004757	Core 149	Solid composite	29.01	28.37	28.69

B2.4.3 Inorganic Analyses

B2.4.3.1 Ion Chromatography. Ion chromatography was performed on samples that had been prepared by water digestion (liquid samples were not digested). Quality control tests included standards, spikes, blanks, and duplicate analyses. The SAP required that the full suite of IC analytes (Br, Cl, F, NO_3, NO_2, oxalate, PO_4, and SO_4) be reported. The results are presented in Tables B2-18 to B2-25.

Table B2-18. Tank 241-S-111 Analytical Results: Bromide (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 1,285	< 1,290	< 1,287.5
S96T005969	149: 2	Drainable liquid	< 527.6	< 528	< 527.8
S96T003362	149: 3	Drainable liquid	< 1,285	< 1,290	< 1,287.5
Solids: water digest			µg/g	µg/g	µg/g
S96T003421	149: 3	Whole	< 1,121	< 1,120	< 1,120.5
S96T003435	149: 4	Upper half	< 1,006	< 1,010	< 1,008
S96T003436		Lower half	< 1,056	< 1,060	< 1,058
S96T003437	149: 5	Upper half	< 927.5	< 932	< 929.75
S96T003438		Lower half	< 966.1	< 971	< 968.55
S96T003439	149: 6	Upper half	< 1,140	< 1,130	< 1,135
S96T003440		Lower half	< 1,055	< 1,050	< 1,052.5
S96T003441	149: 7	Upper half	< 967.8	< 968	< 967.9
S96T003442		Lower half	< 1,086	< 1,080	< 1,083
S96T003443	149: 8	Upper half	< 1,153	< 1,150	< 1,151.5
S96T003444		Lower half	< 1,260	< 1,270	< 1,265
S96T003445	149: 9	Upper half	< 1,061	< 1,070	< 1,065.5
S96T003446		Lower half	< 1,086	< 1,080	< 1,083
S96T003621	149:10	Upper half	< 1,124	< 1,140	< 1,132
S96T003447	149:11	Upper half	< 50.72	< 50.3	< 50.51
S96T004760	Core 149	Solid composite	< 1,137	< 1,130	< 1,133.5

Table B2-19. Tank 241-S-111 Analytical Results: Chloride (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	6,864	6,830	6,847
S96T005969	149: 2	Drainable liquid	6,035	6,650	6,342.5
S96T003362	149: 3	Drainable liquid	5,607	5,660	5,633.5
Solids: water digest			µg/g	µg/g	µg/g
S96T003421	149: 3	Whole	3,769	4,050	3,909.5
S96T003435	149: 4	Upper half	3,126	3,170	3,148
S96T003436		Lower half	3,233	3,260	3,246.5
S96T003437	149: 5	Upper half	2,822	2,830	2,826
S96T003438		Lower half	2,986	2,930	2,958
S96T003439	149: 6	Upper half	2,544	3,120	2,832[QC:e]
S96T003440		Lower half	2,748	2,750	2,749
S96T003441	149: 7	Upper half	3,374	3,580	3,477
S96T003442		Lower half	2,531	2,460	2,495.5
S96T003443	149: 8	Upper half	2,545	4,760	3,652.5[QC:e]
S96T003444		Lower half	2,279	2,530	2,404.5
S96T003445	149: 9	Upper half	3,656	3,620	3,638
S96T003446		Lower half	3,106	3,160	3,133
S96T003621	149:10	Upper half	2,737	2,470	2,603.5
S96T003447	149:11	Upper half	1,607	1,600	1,603.5
S96T004760	Core 149	Solid composite	2,665	2,840	2,752.5

Table B2-20. Tank 241-S-111 Analytical Results: Fluoride (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 132.6	< 133	< 132.8
S96T005969	149: 2	Drainable liquid	< 50.65	< 50.7	< 50.675
S96T003362	149: 3	Drainable liquid	< 132.6	< 133	< 132.8
Solids: water digest			µg/g	µg/g	µg/g
S96T003421	149: 3	Whole	< 115.7	< 115	< 115.35
S96T003435	149: 4	Upper half	2,168	2,440	2,304
S96T003436		Lower half	2,039	2,150	2,094.5
S96T003437	149: 5	Upper half	881.3	945	913.15
S96T003438		Lower half	220.1	236	228.05
S96T003439	149: 6	Upper half	1,624	< 117	< 870.5[QC:e]
S96T003440		Lower half	793.7	698	745.85
S96T003441	149: 7	Upper half	1,002	1,220	1,111
S96T003442		Lower half	< 112	< 112	< 112
S96T003443	149: 8	Upper half	< 118.9	735	< 426.95[QC:e]
S96T003444		Lower half	1,693	< 131	< 912[QC:e]
S96T003445	149: 9	Upper half	1,278	1,420	1,349
S96T003446		Lower half	1,046	843	944.5[QC:e]
S96T003621	149:10	Upper half	< 115.9	< 117	< 116.45
S96T003447	149:11	Upper half	< 5.233	< 5.19	< 5.2115
S96T004760	Core 149	Solid composite	530.6	441	485.8

Table B2-21. Tank 241-S-111 Analytical Results: Nitrate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	2.046E+05	2.030E+05	2.038E+05
S96T005969	149: 2	Drainable liquid	1.772E+05	1.760E+05	1.766E+05
S96T003362	149: 3	Drainable liquid	1.969E+05	1.970E+05	1.970E+05
Solids: water digest			µg/g	µg/g	µg/g
S96T003421	149: 3	Whole	1.830E+05	1.570E+05	1.700E+05
S96T003435	149: 4	Upper half	1.095E+05	1.120E+05	1.108E+05
S96T003436		Lower half	1.108E+05	1.060E+05	1.084E+05
S96T003437	149: 5	Upper half	3.241E+05	2.810E+05	3.026E+05
S96T003438		Lower half	2.436E+05	2.520E+05	2.478E+05
S96T003439	149: 6	Upper half	3.265E+05	3.860E+05	3.563E+05
S96T003440		Lower half	3.633E+05	3.660E+05	3.647E+05
S96T003441	149: 7	Upper half	2.551E+05	2.340E+05	2.446E+05
S96T003442		Lower half	3.678E+05	3.880E+05	3.779E+05
S96T003443	149: 8	Upper half	3.792E+05	3.730E+05	3.761E+05
S96T003444		Lower half	3.552E+05	2.900E+05	3.226E+05[QC:e]
S96T003445	149: 9	Upper half	1.061E+05	1.130E+05	1.096E+05
S96T003446		Lower half	49,570	48,600	49,085
S96T003621	149:10	Upper half	48,650	43,900	46,275
S96T003447	149:11	Upper half	24,520	24,300	24,410
S96T004760	Core 149	Solid composite	2.838E+05	2.500E+05	2.669E+05

Table B2-22. Tank 241-S-111 Analytical Results: Nitrite (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	62,590	62,500	62,545
S96T005969	149: 2	Drainable liquid	74,780	75,600	75,190
S96T003362	149: 3	Drainable liquid	62,110	62,100	62,105
Solids: water digest			µg/g	µg/g	µg/g
S96T003421	149: 3	Whole	40,450	42,900	41,675
S96T003435	149: 4	Upper half	34,230	33,700	33,965
S96T003436		Lower half	34,300	34,700	34,500
S96T003437	149: 5	Upper half	29,940	30,600	30,270
S96T003438		Lower half	32,820	31,900	32,360
S96T003439	149: 6	Upper half	27,760	33,200	30,480
S96T003440		Lower half	29,620	29,300	29,460
S96T003441	149: 7	Upper half	35,540	33,300	34,420
S96T003442		Lower half	26,260	26,200	26,230
S96T003443	149: 8	Upper half	27,610	28,800	28,205
S96T003444		Lower half	24,730	26,200	25,465
S96T003445	149: 9	Upper half	37,690	36,800	37,245
S96T003446		Lower half	30,710	31,900	31,305
S96T003621	149:10	Upper half	27,790	25,800	26,795
S96T003447	149:11	Upper half	15,670	15,400	15,535
S96T004760	Core 149	Solid composite	28,020	30,000	29,010

Table B2-23. Tank 241-S-111 Analytical Results: Oxalate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 1,071	10,700	< 5,885.5[QC:e]
S96T005969	149: 2	Drainable liquid	526.9	643	584.95
S96T003362	149: 3	Drainable liquid	< 1,071	< 1,070	< 1,070.5
Solids: water digest			µg/g	µg/g	µg/g
S96T003421	149: 3	Whole	11,600	11,700	11,650
S96T003435	149: 4	Upper half	12,690	12,200	12,445
S96T003436		Lower half	10,690	12,300	11,495
S96T003437	149: 5	Upper half	5,228	6,480	5,854[QC:e]
S96T003438		Lower half	6,222	5,340	5,781
S96T003439	149: 6	Upper half	5,639	6,810	6,224.5
S96T003440		Lower half	4,658	4,150	4,404
S96T003441	149: 7	Upper half	8,988	8,640	8,814
S96T003442		Lower half	4,240	4,160	4,200
S96T003443	149: 8	Upper half	4,796	5,100	4,948
S96T003444		Lower half	5,230	5,560	5,395
S96T003445	149: 9	Upper half	6,687	6,570	6,628.5
S96T003446		Lower half	2,263	1,930	2,096.5
S96T003621	149:10	Upper half	< 936.3	< 948	< 942.15
S96T003447	149:11	Upper half	484.7	175	329.85[QC:e]
S96T004760	Core 149	Solid composite	4,667	4,080	4,373.5

Table B2-24. Tank 241-S-111 Analytical Results: Phosphate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	2,874	3,040	2,957
S96T005969	149: 2	Drainable liquid	3,358	2,070	2,714[QC:e]
S96T003362	149: 3	Drainable liquid	3,278	< 1,210	< 2,244[QC:e]
Solids: water digest			µg/g	µg/g	µg/g
S96T003421	149: 3	Whole	5,579	9,230	7,404.5[QC:e]
S96T003435	149: 4	Upper half	17,030	20,200	18,615
S96T003436		Lower half	15,480	17,000	16,240
S96T003437	149: 5	Upper half	3,676	3,900	3,788
S96T003438		Lower half	7,365	7,730	7,547.5
S96T003439	149: 6	Upper half	16,770	6,500	11,635[QC:e]
S96T003440		Lower half	1,458	1,380	1,419
S96T003441	149: 7	Upper half	5,774	7,180	6,477[QC:e]
S96T003442		Lower half	1,368	< 1,020	< 1,194[QC:e]
S96T003443	149: 8	Upper half	2,314	4,170	3,242[QC:e]
S96T003444		Lower half	15,140	27,400	21,270[QC:e]
S96T003445	149: 9	Upper half	11,120	12,700	11,910
S96T003446		Lower half	22,210	21,000	21,605
S96T003621	149:10	Upper half	< 1,060	< 1,070	< 1,065
S96T003447	149:11	Upper half	2,162	2,010	2,086
S96T004760	Core 149	Solid composite	8,078	6,980	7,529

Table B2-25. Tank 241-S-111 Analytical Results: Sulfate (IC).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	4,756	5,160	4,958
S96T005969	149: 2	Drainable liquid	4,594	4,200	4,397
S96T003362	149: 3	Drainable liquid	4,435	4,550	4,492.5
Solids: water digest			µg/g	µg/g	µg/g
S96T003421	149: 3	Whole	5,562	6,110	5,836
S96T003435	149: 4	Upper half	29,440	27,300	28,370
S96T003436		Lower half	35,330	35,600	35,465
S96T003437	149: 5	Upper half	19,050	23,400	21,225[QC:e]
S96T003438		Lower half	21,010	18,500	19,755
S96T003439	149: 6	Upper half	17,390	20,800	19,095
S96T003440		Lower half	12,910	13,000	12,955
S96T003441	149: 7	Upper half	29,620	27,200	28,410
S96T003442		Lower half	15,090	15,200	15,145
S96T003443	149: 8	Upper half	16,380	18,200	17,290
S96T003444		Lower half	19,750	20,300	20,025
S96T003445	149: 9	Upper half	59,070	59,200	59,135
S96T003446		Lower half	4,850	4,820	4,835
S96T003621	149:10	Upper half	< 1,212	< 1,230	< 1,221
S96T003447	149:11	Upper half	190.8	191	190.9
S96T004760	Core 149	Solid composite	16,270	16,100	16,185

B2.4.3.2 Inductively Coupled Plasma Spectroscopy. Inductively coupled plasma spectrometry was initially performed on samples that had been prepared by an acid digestion (except liquid samples, which were analyzed directly). Because of poor dissolution in acid solution, subsamples from segments 9 through 11 of core 149 were also fusion digested by the KOH fusion method and analyzed by ICP. Fusion-digested data for potassium were deleted because potassium was added for the fusion. Fusion-digested data for nickel should be used with caution because the samples were prepared in a nickel crucible. Acid, water, and fusion digestions were performed on the core 149 solids composite sample. Quality control tests included standards, blanks, spikes, and duplicate analyses. The SAP required that the full suite of ICP elements be analyzed and reported. The results are presented in Tables B2-26 to B2-62.

Table B2-26. Tank 241-S-111 Analytical Results: Aluminum (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	24,800	25,000	24,900[QC:c]
S96T003361	149: 2	Drainable liquid	25,700	25,700	25,700
S96T003362	149: 3	Drainable liquid	24,800	24,800	24,800
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	20,700	21,400	21,050
S96T003422	149: 4	Upper half	16,100	16,100	16,100
S96T003423		Lower half	16,800	17,000	16,900
S96T003424	149: 5	Upper half	14,900	15,300	15,100
S96T003425		Lower half	15,800	16,500	16,150
S96T003426	149: 6	Upper half	14,500	14,500	14,500
S96T003427		Lower half	14,200	14,000	14,100
S96T003428	149: 7	Upper half	15,400	16,200	15,800
S96T003429		Lower half	13,200	13,400	13,300
S96T003430	149: 8	Upper half	13,900	14,900	14,400
S96T003431		Lower half	13,500	14,500	14,000
S96T003432	149: 9	Upper half	21,200	21,200	21,200
S96T003433		Lower half	16,900	29,400	23,150[QC:e]
S96T003620	149:10	Upper half	54,000	59,100	56,550[QC:d]
S96T003434	149:11	Upper half	26,500	14,800	20,650[QC:d,e]
S96T004759	Core 149	Solid composite	25,900	32,000	28,950[QC:d,e]
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	23,100	24,400	23,750
S96T003412		Lower half	1.480E+05	1.510E+05	1.495E+05
S96T003619	149:10	Upper half	2.340E+05	2.400E+05	2.370E+05
S96T003413	149:11	Upper half	2.610E+05	2.590E+05	2.600E+05
S96T004758	Core 149	Solid composite	52,900	58,600	55,750
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	14,300	15,300	14,800

Table B2-27. Tank 241-S-111 Analytical Results: Antimony (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 24.1	< 24.1	< 24.1
S96T003361	149: 2	Drainable liquid	< 24.1	< 24.1	< 24.1
S96T003362	149: 3	Drainable liquid	< 24.1	< 24.1	< 24.1
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 28.6	< 29.1	< 28.85
S96T003422	149: 4	Upper half	< 23.1	< 22.5	< 22.8
S96T003423		Lower half	< 23.8	< 23.9	< 23.85
S96T003424	149: 5	Upper half	< 25.8	< 26	< 25.9
S96T003425		Lower half	< 22.5	< 23	< 22.75
S96T003426	149: 6	Upper half	< 21.5	< 20.6	< 21.05
S96T003427		Lower half	< 30.8	< 30.7	< 30.75
S96T003428	149: 7	Upper half	< 30.5	< 30	< 30.25
S96T003429		Lower half	< 31.2	< 31	< 31.1
S96T003430	149: 8	Upper half	< 34.1	< 36.2	< 35.15
S96T003431		Lower half	< 32.9	< 33.8	< 33.35
S96T003432	149: 9	Upper half	< 30.3	< 30.3	< 30.3
S96T003433		Lower half	< 30.1	< 30.1	< 30.1
S96T003620	149:10	Upper half	< 12.1	< 12.4	< 12.25
S96T003434	149:11	Upper half	< 28.4	< 28	< 28.2
S96T004759	Core 149	Solid composite	< 22.7	< 22.4	< 22.55
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 1,260	< 1,260	< 1,260
S96T003412		Lower half	< 1,220	< 1,240	< 1,230
S96T003619	149:10	Upper half	< 1,290	< 1,300	< 1,295
S96T003413	149:11	Upper half	< 1,210	< 1,220	< 1,215
S96T004758	Core 149	Solid composite	< 1,320	< 1,330	< 1,325
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 22	< 21.9	< 21.95

Table B2-28. Tank 241-S-111 Analytical Results: Arsenic (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003361	149: 2	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003362	149: 3	Drainable liquid	< 40.1	< 40.1	< 40.1
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 47.6	< 48.4	< 48
S96T003422	149: 4	Upper half	< 38.5	< 37.6	< 38.05
S96T003423		Lower half	< 39.7	< 39.8	< 39.75
S96T003424	149: 5	Upper half	< 43	< 43.4	< 43.2
S96T003425		Lower half	< 37.5	< 38.4	< 37.95
S96T003426	149: 6	Upper half	< 35.8	< 34.3	< 35.05
S96T003427		Lower half	< 51.3	< 51.2	< 51.25
S96T003428	149: 7	Upper half	< 50.8	< 49.9	< 50.35
S96T003429		Lower half	< 52	< 51.7	< 51.85
S96T003430	149: 8	Upper half	< 56.8	< 60.3	< 58.55
S96T003431		Lower half	< 54.8	< 56.4	< 55.6
S96T003432	149: 9	Upper half	< 50.5	< 50.4	< 50.45
S96T003433		Lower half	< 50.2	< 50.2	< 50.2
S96T003620	149:10	Upper half	< 20.1	< 20.7	< 20.4
S96T003434	149:11	Upper half	< 47.3	< 46.7	< 47
S96T004759	Core 149	Solid composite	< 37.9	< 37.3	< 37.6
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 2,090	< 2,100	< 2,095
S96T003412		Lower half	< 2,040	< 2,060	< 2,050
S96T003619	149:10	Upper half	< 2,160	< 2,160	< 2,160
S96T003413	149:11	Upper half	< 2,010	< 2,030	< 2,020
S96T004758	Core 149	Solid composite	< 2,200	< 2,220	< 2,210
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 36.6	< 36.5	< 36.55

Table B2-29. Tank 241-S-111 Analytical Results: Barium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 20.1	< 20.1	< 20.1
S96T003361	149: 2	Drainable liquid	< 20.1	< 20.1	< 20.1
S96T003362	149: 3	Drainable liquid	< 20.1	< 20.1	< 20.1
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 23.8	< 24.2	< 24
S96T003422	149: 4	Upper half	< 19.3	< 18.8	< 19.05
S96T003423		Lower half	< 19.8	< 19.9	< 19.85
S96T003424	149: 5	Upper half	< 21.5	< 21.7	< 21.6
S96T003425		Lower half	< 18.7	< 19.2	< 18.95
S96T003426	149: 6	Upper half	< 17.9	< 17.2	< 17.55
S96T003427		Lower half	< 25.7	< 25.6	< 25.65
S96T003428	149: 7	Upper half	< 25.4	< 25	< 25.2
S96T003429		Lower half	< 26	< 25.8	< 25.9
S96T003430	149: 8	Upper half	< 28.4	< 30.1	< 29.25
S96T003431		Lower half	< 27.4	< 28.2	< 27.8
S96T003432	149: 9	Upper half	< 25.3	< 25.2	< 25.25
S96T003433		Lower half	< 25.1	< 25.1	< 25.1
S96T003620	149:10	Upper half	< 10.1	< 10.3	< 10.2
S96T003434	149:11	Upper half	< 23.6	< 23.4	< 23.5
S96T004759	Core 149	Solid composite	< 18.9	< 18.7	< 18.8
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 1,050	< 1,050	< 1,050
S96T003412		Lower half	< 1,020	< 1,030	< 1,025
S96T003619	149:10	Upper half	< 1,080	< 1,080	< 1,080
S96T003413	149:11	Upper half	< 1,010	< 1,010	< 1,010
S96T004758	Core 149	Solid composite	< 1,100	< 1,110	< 1,105
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 18.3	< 18.3	< 18.3

Table B2-30. Tank 241-S-111 Analytical Results: Beryllium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 2	< 2	< 2
S96T003361	149: 2	Drainable liquid	< 2	< 2	< 2
S96T003362	149: 3	Drainable liquid	< 2	< 2	< 2
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 2.38	< 2.42	< 2.4
S96T003422	149: 4	Upper half	< 1.93	< 1.88	< 1.905
S96T003423		Lower half	< 1.98	< 1.99	< 1.985
S96T003424	149: 5	Upper half	< 2.15	< 2.17	< 2.16
S96T003425		Lower half	< 1.87	< 1.92	< 1.895
S96T003426	149: 6	Upper half	< 1.79	< 1.72	< 1.755
S96T003427		Lower half	< 2.57	< 2.56	< 2.565
S96T003428	149: 7	Upper half	< 2.54	< 2.5	< 2.52
S96T003429		Lower half	< 2.6	< 2.58	< 2.59
S96T003430	149: 8	Upper half	< 2.84	< 3.01	< 2.925
S96T003431		Lower half	< 2.74	< 2.82	< 2.78
S96T003432	149: 9	Upper half	< 2.53	< 2.52	< 2.525
S96T003433		Lower half	< 2.51	< 2.51	< 2.51
S96T003620	149:10	Upper half	< 1.01	< 1.03	< 1.02
S96T003434	149:11	Upper half	< 2.36	< 2.34	< 2.35
S96T004759	Core 149	Solid composite	< 1.89	< 1.87	< 1.88
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 105	< 105	< 105
S96T003412		Lower half	< 102	< 103	< 102.5
S96T003619	149:10	Upper half	< 108	< 108	< 108
S96T003413	149:11	Upper half	< 101	< 101	< 101
S96T004758	Core 149	Solid composite	< 110	< 111	< 110.5
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 1.83	< 1.83	< 1.83

Table B2-31. Tank 241-S-111 Analytical Results: Bismuth (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003361	149: 2	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003362	149: 3	Drainable liquid	< 40.1	< 40.1	< 40.1
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	77.3	73	75.15
S96T003422	149: 4	Upper half	124	112	118
S96T003423		Lower half	82.4	99	90.7
S96T003424	149: 5	Upper half	< 43	< 43.4	< 43.2
S96T003425		Lower half	47.8	43.5	45.65
S96T003426	149: 6	Upper half	< 35.8	< 34.3	< 35.05
S96T003427		Lower half	< 51.3	< 51.2	< 51.25
S96T003428	149: 7	Upper half	< 50.8	< 49.9	< 50.35
S96T003429		Lower half	< 52	< 51.7	< 51.85
S96T003430	149: 8	Upper half	< 56.8	< 60.3	< 58.55
S96T003431		Lower half	< 54.8	< 56.4	< 55.6
S96T003432	149: 9	Upper half	< 50.5	< 50.4	< 50.45
S96T003433		Lower half	< 50.2	< 50.2	< 50.2
S96T003620	149:10	Upper half	< 20.1	< 20.7	< 20.4
S96T003434	149:11	Upper half	< 47.3	< 46.7	< 47
S96T004759	Core 149	Solid composite	38.4	< 37.3	< 37.85
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 2,090	< 2,100	< 2,095
S96T003412		Lower half	< 2,040	< 2,060	< 2,050
S96T003619	149:10	Upper half	< 2,160	< 2,160	< 2,160
S96T003413	149:11	Upper half	< 2,010	< 2,030	< 2,020
S96T004758	Core 149	Solid composite	< 2,200	< 2,220	< 2,210
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 36.6	< 36.5	< 36.55

Table B2-32. Tank 241-S-111 Analytical Results: Boron (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	76	79.8	77.9
S96T003361	149: 2	Drainable liquid	81.1	78.8	79.95
S96T003362	149: 3	Drainable liquid	75	76.9	75.95
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	142	179	160.5[QC:e]
S96T003422	149: 4	Upper half	127	153	140
S96T003423		Lower half	111	97.3	104.15
S96T003424	149: 5	Upper half	146	96.6	121.3[QC:e]
S96T003425		Lower half	148	108	128[QC:e]
S96T003426	149: 6	Upper half	108	106	107
S96T003427		Lower half	97.7	115	106.35
S96T003428	149: 7	Upper half	99.1	118	108.55
S96T003429		Lower half	79.6	123	101.3[QC:e]
S96T003430	149: 8	Upper half	93.2	99.7	96.45
S96T003431		Lower half	110	111	110.5
S96T003432	149: 9	Upper half	112	103	107.5
S96T003433		Lower half	39.2	56.3	47.75[QC:e]
S96T003620	149:10	Upper half	79.8	89.9	84.85
S96T003434	149:11	Upper half	50.5	32.2	41.35[QC:e]
S96T004759	Core 149	Solid composite	151	128	139.5
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 1,050	< 1,050	< 1,050
S96T003412		Lower half	< 1,020	< 1,030	< 1,025
S96T003619	149:10	Upper half	< 1,080	< 1,080	< 1,080
S96T003413	149:11	Upper half	< 1,010	< 1,010	< 1,010
S96T004758	Core 149	Solid composite	< 1,100	< 1,110	< 1,105
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	599	441	520[QC:e]

Table B2-33. Tank 241-S-111 Analytical Results: Cadmium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 2	< 2	< 2
S96T003361	149: 2	Drainable liquid	< 2	< 2	< 2
S96T003362	149: 3	Drainable liquid	< 2	< 2	< 2
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	9.53	9.12	9.325
S96T003422	149: 4	Upper half	15.2	16.2	15.7
S96T003423		Lower half	12.3	12.9	12.6
S96T003424	149: 5	Upper half	4.66	4.57	4.615
S96T003425		Lower half	5.78	5.5	5.64
S96T003426	149: 6	Upper half	4.38	4.16	4.27
S96T003427		Lower half	3.8	3.84	3.82
S96T003428	149: 7	Upper half	5.3	5.49	5.395
S96T003429		Lower half	3.14	< 2.58	< 2.86
S96T003430	149: 8	Upper half	3.63	4.01	3.82
S96T003431		Lower half	3.85	3.31	3.58
S96T003432	149: 9	Upper half	5.5	4.76	5.13
S96T003433		Lower half	< 2.51	4.57	< 3.54[QC:e]
S96T003620	149:10	Upper half	1.06	1.09	1.075
S96T003434	149:11	Upper half	4.62	< 2.34	< 3.48[QC:e]
S96T004759	Core 149	Solid composite	3.1	3.23	3.165
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 105	< 105	< 105
S96T003412		Lower half	< 102	< 103	< 102.5
S96T003619	149:10	Upper half	< 108	< 108	< 108
S96T003413	149:11	Upper half	< 101	< 101	< 101
S96T004758	Core 149	Solid composite	< 110	< 111	< 110.5
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 1.83	< 1.83	< 1.83

Table B2-34. Tank 241-S-111 Analytical Results: Calcium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	274	187	230.5[QC:e]
S96T003422	149: 4	Upper half	226	229	227.5
S96T003423		Lower half	215	219	217
S96T003424	149: 5	Upper half	135	130	132.5
S96T003425		Lower half	143	138	140.5
S96T003426	149: 6	Upper half	128	118	123
S96T003427		Lower half	144	123	133.5
S96T003428	149: 7	Upper half	185	155	170
S96T003429		Lower half	99.8	96.4	98.1
S96T003430	149: 8	Upper half	116	137	126.5
S96T003431		Lower half	102	116	109
S96T003432	149: 9	Upper half	187	196	191.5
S96T003433		Lower half	140	168	154
S96T003620	149:10	Upper half	158	195	176.5[QC:e]
S96T003434	149:11	Upper half	171	123	147[QC:e]
S96T004759	Core 149	Solid composite	223	412	317.5[QC:e]
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003361	149: 2	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003362	149: 3	Drainable liquid	< 40.1	< 40.1	< 40.1
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 2,090	< 2,100	< 2,095
S96T003412		Lower half	< 2,040	< 2,060	< 2,050
S96T003619	149:10	Upper half	< 2,160	< 2,160	< 2,160
S96T003413	149:11	Upper half	< 2,010	< 2,030	< 2,020
S96T004758	Core 149	Solid composite	< 2,200	< 2,220	< 2,210
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 36.6	< 36.5	< 36.55

Table B2-35. Tank 241-S-111 Analytical Results: Cerium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003361	149: 2	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003362	149: 3	Drainable liquid	< 40.1	< 40.1	< 40.1
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 47.6	< 48.4	< 48
S96T003422	149: 4	Upper half	< 38.5	< 37.6	< 38.05
S96T003423		Lower half	< 39.7	< 39.8	< 39.75
S96T003424	149: 5	Upper half	< 43	< 43.4	< 43.2
S96T003425		Lower half	< 37.5	< 38.4	< 37.95
S96T003426	149: 6	Upper half	< 35.8	< 34.3	< 35.05
S96T003427		Lower half	< 51.3	< 51.2	< 51.25
S96T003428	149: 7	Upper half	< 50.8	< 49.9	< 50.35
S96T003429		Lower half	< 52	< 51.7	< 51.85
S96T003430	149: 8	Upper half	< 56.8	< 60.3	< 58.55
S96T003431		Lower half	< 54.8	< 56.4	< 55.6
S96T003432	149: 9	Upper half	< 50.5	< 50.4	< 50.45
S96T003433		Lower half	< 50.2	< 50.2	< 50.2
S96T003620	149:10	Upper half	< 20.1	< 20.7	< 20.4
S96T003434	149:11	Upper half	< 47.3	< 46.7	< 47
S96T004759	Core 149	Solid composite	< 37.9	< 37.3	< 37.6
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 2,090	< 2,100	< 2,095
S96T003412		Lower half	< 2,040	< 2,060	< 2,050
S96T003619	149:10	Upper half	< 2,160	< 2,160	< 2,160
S96T003413	149:11	Upper half	< 2,010	< 2,030	< 2,020
S96T004758	Core 149	Solid composite	< 2,200	< 2,220	< 2,210
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 36.6	< 36.5	< 36.55

Table B2-36. Tank 241-S-111 Analytical Results: Chromium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			μg/mL	μg/mL	μg/mL
S96T003360	149: 1	Drainable liquid	4,350	4,380	4,365
S96T003361	149: 2	Drainable liquid	4,540	4,500	4,520
S96T003362	149: 3	Drainable liquid	4,300	4,310	4,305
Solids: acid digest			μg/g	μg/g	μg/g
S96T003420	149: 3	Whole	12,500	13,000	12,750
S96T003422	149: 4	Upper half	9,870	10,000	9,935
S96T003423		Lower half	8,190	8,920	8,555
S96T003424	149: 5	Upper half	4,740	4,820	4,780
S96T003425		Lower half	5,230	5,530	5,380
S96T003426	149: 6	Upper half	4,780	4,450	4,615
S96T003427		Lower half	3,790	3,810	3,800
S96T003428	149: 7	Upper half	5,680	5,950	5,815
S96T003429		Lower half	3,430	3,500	3,465
S96T003430	149: 8	Upper half	3,890	4,250	4,070
S96T003431		Lower half	4,150	4,320	4,235
S96T003432	149: 9	Upper half	6,770	6,820	6,795
S96T003433		Lower half	2,030	5,870	3,950[QC:e]
S96T003620	149:10	Upper half	1,820	1,860	1,840
S96T003434	149:11	Upper half	5,450	1,610	3,530[QC:e]
S96T004759	Core 149	Solid composite	4,150	4,290	4,220[QC:c]
Solids: fusion			μg/g	μg/g	μg/g
S96T003419	149: 9	Upper half	6,980	7,490	7,235
S96T003412		Lower half	6,450	6,670	6,560
S96T003619	149:10	Upper half	2,260	2,320	2,290
S96T003413	149:11	Upper half	2,220	2,170	2,195
S96T004758	Core 149	Solid composite	4,120	4,240	4,180
Solids: water digest			μg/g	μg/g	μg/g
S96T004761	Core 149	Solid composite	991	1,070	1,030.5

Table B2-37. Tank 241-S-111 Analytical Results: Cobalt (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 8.02	< 8.02	< 8.02
S96T003361	149: 2	Drainable liquid	< 8.02	< 8.02	< 8.02
S96T003362	149: 3	Drainable liquid	< 8.02	< 8.02	< 8.02
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 9.52	< 9.69	< 9.605
S96T003422	149: 4	Upper half	< 7.7	< 7.51	< 7.605
S96T003423		Lower half	< 7.93	< 7.96	< 7.945
S96T003424	149: 5	Upper half	< 8.61	< 8.68	< 8.645
S96T003425		Lower half	< 7.5	< 7.67	< 7.585
S96T003426	149: 6	Upper half	< 7.16	< 6.86	< 7.01
S96T003427		Lower half	< 10.3	< 10.2	< 10.25
S96T003428	149: 7	Upper half	< 10.2	< 9.98	< 10.09
S96T003429		Lower half	< 10.4	< 10.3	< 10.35
S96T003430	149: 8	Upper half	< 11.4	< 12.1	< 11.75
S96T003431		Lower half	< 11	< 11.3	< 11.15
S96T003432	149: 9	Upper half	< 10.1	< 10.1	< 10.1
S96T003433		Lower half	< 10	< 10	< 10
S96T003620	149:10	Upper half	< 4.02	< 4.13	< 4.075
S96T003434	149:11	Upper half	< 9.46	< 9.35	< 9.405
S96T004759	Core 149	Solid composite	< 7.58	< 7.46	< 7.52
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 419	< 420	< 419.5
S96T003412		Lower half	< 407	< 412	< 409.5
S96T003619	149:10	Upper half	< 431	< 433	< 432
S96T003413	149:11	Upper half	< 402	< 406	< 404
S96T004758	Core 149	Solid composite	< 439	< 444	< 441.5
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 7.32	< 7.31	< 7.315

Table B2-38. Tank 241-S-111 Analytical Results: Copper (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			μg/mL	μg/mL	μg/mL
S96T003360	149: 1	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003361	149: 2	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003362	149: 3	Drainable liquid	< 4.01	< 4.01	< 4.01
Solids: acid digest			μg/g	μg/g	μg/g
S96T003420	149: 3	Whole	< 4.76	< 4.84	< 4.8
S96T003422	149: 4	Upper half	< 3.85	< 3.76	< 3.805
S96T003423		Lower half	< 3.97	< 3.98	< 3.975
S96T003424	149: 5	Upper half	< 4.3	< 4.34	< 4.32
S96T003425		Lower half	< 3.75	< 3.84	< 3.795
S96T003426	149: 6	Upper half	< 3.58	< 3.43	< 3.505
S96T003427		Lower half	< 5.13	< 5.12	< 5.125
S96T003428	149: 7	Upper half	< 5.08	< 4.99	< 5.035
S96T003429		Lower half	< 5.2	< 5.17	< 5.185
S96T003430	149: 8	Upper half	< 5.68	< 6.03	< 5.855
S96T003431		Lower half	< 5.48	< 5.64	< 5.56
S96T003432	149: 9	Upper half	< 5.05	< 5.04	< 5.045
S96T003433		Lower half	< 5.02	< 5.02	< 5.02
S96T003620	149:10	Upper half	< 2.01	< 2.07	< 2.04
S96T003434	149:11	Upper half	< 4.73	< 4.67	< 4.7
S96T004759	Core 149	Solid composite	< 3.79	< 3.73	< 3.76
Solids: fusion			μg/g	μg/g	μg/g
S96T003419	149: 9	Upper half	< 209	< 210	< 209.5
S96T003412		Lower half	< 204	< 206	< 205
S96T003619	149:10	Upper half	< 216	< 216	< 216
S96T003413	149:11	Upper half	< 201	< 203	< 202
S96T004758	Core 149	Solid composite	< 220	< 222	< 221
Solids: water digest			μg/g	μg/g	μg/g
S96T004761	Core 149	Solid composite	< 3.66	< 3.65	< 3.655

Table B2-39. Tank 241-S-111 Analytical Results: Iron (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 20.1	< 20.1	< 20.1
S96T003361	149: 2	Drainable liquid	< 20.1	< 20.1	< 20.1
S96T003362	149: 3	Drainable liquid	< 20.1	< 20.1	< 20.1
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	344	328	336
S96T003422	149: 4	Upper half	1,950	324	1,137[QC:e]
S96T003423		Lower half	198	213	205.5
S96T003424	149: 5	Upper half	102	117	109.5
S96T003425		Lower half	119	125	122
S96T003426	149: 6	Upper half	122	106	114
S96T003427		Lower half	77.4	117	97.2[QC:e]
S96T003428	149: 7	Upper half	148	148	148
S96T003429		Lower half	74.5	76.6	75.55
S96T003430	149: 8	Upper half	130	91.5	110.75[QC:e]
S96T003431		Lower half	96.6	102	99.3
S96T003432	149: 9	Upper half	160	160	160
S96T003433		Lower half	25.6	130	77.8[QC:e]
S96T003620	149:10	Upper half	21	22.2	21.6
S96T003434	149:11	Upper half	123	23.4	73.2[QC:e]
S96T004759	Core 149	Solid composite	77.6	110	93.8[QC:e]
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 1,050	< 1,050	< 1,050
S96T003412		Lower half	< 1,020	< 1,030	< 1,025
S96T003619	149:10	Upper half	< 1,080	< 1,080	< 1,080
S96T003413	149:11	Upper half	< 1,010	< 1,010	< 1,010
S96T004758	Core 149	Solid composite	< 1,100	< 1,110	< 1,105
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 18.3	< 18.3	< 18.3

Table B2-40. Tank 241-S-111 Analytical Results: Lanthanum (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 20.1	< 20.1	< 20.1
S96T003361	149: 2	Drainable liquid	< 20.1	< 20.1	< 20.1
S96T003362	149: 3	Drainable liquid	< 20.1	< 20.1	< 20.1
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 23.8	< 24.2	< 24
S96T003422	149: 4	Upper half	< 19.3	< 18.8	< 19.05
S96T003423		Lower half	< 19.8	< 19.9	< 19.85
S96T003424	149: 5	Upper half	< 21.5	< 21.7	< 21.6
S96T003425		Lower half	< 18.7	< 19.2	< 18.95
S96T003426	149: 6	Upper half	< 17.9	< 17.2	< 17.55
S96T003427		Lower half	< 25.7	< 25.6	< 25.65
S96T003428	149: 7	Upper half	< 25.4	< 25	< 25.2
S96T003429		Lower half	< 26	< 25.8	< 25.9
S96T003430	149: 8	Upper half	< 28.4	< 30.1	< 29.25
S96T003431		Lower half	< 27.4	< 28.2	< 27.8
S96T003432	149: 9	Upper half	< 25.3	< 25.2	< 25.25
S96T003433		Lower half	< 25.1	< 25.1	< 25.1
S96T003620	149:10	Upper half	< 10.1	< 10.3	< 10.2
S96T003434	149:11	Upper half	< 23.6	< 23.4	< 23.5
S96T004759	Core 149	Solid composite	< 18.9	< 18.7	< 18.8
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 1,050	< 1,050	< 1,050
S96T003412		Lower half	< 1,020	< 1,030	< 1,025
S96T003619	149:10	Upper half	< 1,080	< 1,080	< 1,080
S96T003413	149:11	Upper half	< 1,010	< 1,010	< 1,010
S96T004758	Core 149	Solid composite	< 1,100	< 1,110	< 1,105
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 18.3	< 18.3	< 18.3

Table B2-41. Tank 241-S-111 Analytical Results: Lead (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003361	149: 2	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003362	149: 3	Drainable liquid	< 40.1	< 40.1	< 40.1
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 47.6	< 48.4	< 48
S96T003422	149: 4	Upper half	42.8	39.6	41.2
S96T003423		Lower half	< 39.7	< 39.8	< 39.75
S96T003424	149: 5	Upper half	< 43	< 43.4	< 43.2
S96T003425		Lower half	< 37.5	< 38.4	< 37.95
S96T003426	149: 6	Upper half	< 35.8	< 34.3	< 35.05
S96T003427		Lower half	< 51.3	< 51.2	< 51.25
S96T003428	149: 7	Upper half	< 50.8	< 49.9	< 50.35
S96T003429		Lower half	< 52	< 51.7	< 51.85
S96T003430	149: 8	Upper half	< 56.8	< 60.3	< 58.55
S96T003431		Lower half	< 54.8	< 56.4	< 55.6
S96T003432	149: 9	Upper half	< 50.5	< 50.4	< 50.45
S96T003433		Lower half	< 50.2	< 50.2	< 50.2
S96T003620	149:10	Upper half	< 20.1	< 20.7	< 20.4
S96T003434	149:11	Upper half	< 47.3	< 46.7	< 47
S96T004759	Core 149	Solid composite	< 37.9	< 37.3	< 37.6
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 2,090	< 2,100	< 2,095
S96T003412		Lower half	< 2,040	< 2,060	< 2,050
S96T003619	149:10	Upper half	< 2,160	< 2,160	< 2,160
S96T003413	149:11	Upper half	< 2,010	< 2,030	< 2,020
S96T004758	Core 149	Solid composite	< 2,200	< 2,220	< 2,210
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 36.6	< 36.5	< 36.55

Table B2-42. Tank 241-S-111 Analytical Results: Lithium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003361	149: 2	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003362	149: 3	Drainable liquid	< 4.01	< 4.01	< 4.01
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 4.76	< 4.84	< 4.8
S96T003422	149: 4	Upper half	< 3.85	< 3.76	< 3.805
S96T003423		Lower half	< 3.97	< 3.98	< 3.975
S96T003424	149: 5	Upper half	< 4.3	< 4.34	< 4.32
S96T003425		Lower half	< 3.75	< 3.84	< 3.795
S96T003426	149: 6	Upper half	< 3.58	< 3.43	< 3.505
S96T003427		Lower half	< 5.13	< 5.12	< 5.125
S96T003428	149: 7	Upper half	< 5.08	< 4.99	< 5.035
S96T003429		Lower half	< 5.2	< 5.17	< 5.185
S96T003430	149: 8	Upper half	< 5.68	< 6.03	< 5.855
S96T003431		Lower half	< 5.48	< 5.64	< 5.56
S96T003432	149: 9	Upper half	< 5.05	< 5.04	< 5.045
S96T003433		Lower half	< 5.02	< 5.02	< 5.02
S96T003620	149:10	Upper half	< 2.01	< 2.07	< 2.04
S96T003434	149:11	Upper half	< 4.73	< 4.67	< 4.7
S96T004759	Core 149	Solid composite	< 3.79	< 3.73	< 3.76
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 209	< 210	< 209.5
S96T003412		Lower half	< 204	< 206	< 205
S96T003619	149:10	Upper half	< 216	< 216	< 216
S96T003413	149:11	Upper half	< 201	< 203	< 202
S96T004758	Core 149	Solid composite	< 220	< 222	< 221
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 3.66	< 3.65	< 3.655

Table B2-43. Tank 241-S-111 Analytical Results: Magnesium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			μg/mL	μg/mL	μg/mL
S96T003360	149: 1	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003361	149: 2	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003362	149: 3	Drainable liquid	< 40.1	< 40.1	< 40.1
Solids: acid digest			μg/g	μg/g	μg/g
S96T003420	149: 3	Whole	< 47.6	< 48.4	< 48
S96T003422	149: 4	Upper half	< 38.5	< 37.6	< 38.05
S96T003423		Lower half	< 39.7	< 39.8	< 39.75
S96T003424	149: 5	Upper half	< 43	< 43.4	< 43.2
S96T003425		Lower half	< 37.5	< 38.4	< 37.95
S96T003426	149: 6	Upper half	< 35.8	< 34.3	< 35.05
S96T003427		Lower half	< 51.3	< 51.2	< 51.25
S96T003428	149: 7	Upper half	< 50.8	< 49.9	< 50.35
S96T003429		Lower half	< 52	< 51.7	< 51.85
S96T003430	149: 8	Upper half	< 56.8	< 60.3	< 58.55
S96T003431		Lower half	< 54.8	< 56.4	< 55.6
S96T003432	149: 9	Upper half	< 50.5	< 50.4	< 50.45
S96T003433		Lower half	< 50.2	< 50.2	< 50.2
S96T003620	149:10	Upper half	< 20.1	< 20.7	< 20.4
S96T003434	149:11	Upper half	< 47.3	< 46.7	< 47
S96T004759	Core 149	Solid composite	< 37.9	< 37.3	< 37.6
Solids: fusion			μg/g	μg/g	μg/g
S96T003419	149: 9	Upper half	< 2,090	< 2,100	< 2,095
S96T003412		Lower half	< 2,040	< 2,060	< 2,050
S96T003619	149:10	Upper half	< 2,160	< 2,160	< 2,160
S96T003413	149:11	Upper half	< 2,010	< 2,030	< 2,020
S96T004758	Core 149	Solid composite	< 2,200	< 2,220	< 2,210
Solids: water digest			μg/g	μg/g	μg/g
S96T004761	Core 149	Solid composite	< 36.6	< 36.5	< 36.55

Table B2-44. Tank 241-S-111 Analytical Results: Manganese (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003361	149: 2	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003362	149: 3	Drainable liquid	< 4.01	< 4.01	< 4.01
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	68.2	70.3	69.25
S96T003422	149: 4	Upper half	104	100	102
S96T003423		Lower half	83.9	92.4	88.15
S96T003424	149: 5	Upper half	37.8	38.2	38
S96T003425		Lower half	44.2	46	45.1
S96T003426	149: 6	Upper half	43.3	40.1	41.7
S96T003427		Lower half	31	31	31
S96T003428	149: 7	Upper half	53.3	55.1	54.2
S96T003429		Lower half	23.1	23.5	23.3
S96T003430	149: 8	Upper half	35.5	36.8	36.15
S96T003431		Lower half	77.8	75.7	76.75
S96T003432	149: 9	Upper half	212	213	212.5
S96T003433		Lower half	< 5.02	93.9	< 49.46[QC:e]
S96T003620	149:10	Upper half	2.2	< 2.07	< 2.135
S96T003434	149:11	Upper half	90	< 4.67	< 47.335[QC:e]
S96T004759	Core 149	Solid composite	40.5	57.7	49.1[QC:e]
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	221	266	243.5
S96T003412		Lower half	< 204	< 206	< 205
S96T003619	149:10	Upper half	< 216	< 216	< 216
S96T003413	149:11	Upper half	< 201	< 203	< 202
S96T004758	Core 149	Solid composite	< 220	< 222	< 221
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 3.66	< 3.65	< 3.655

Table B2-45. Tank 241-S-111 Analytical Results: Molybdenum (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	63.9	65.1	64.5
S96T003361	149: 2	Drainable liquid	67.7	65.1	66.4
S96T003362	149: 3	Drainable liquid	64.4	64.4	64.4
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	41.3	41.9	41.6
S96T003422	149: 4	Upper half	34	33.1	33.55
S96T003423		Lower half	33.2	35.4	34.3
S96T003424	149: 5	Upper half	31.1	30.2	30.65
S96T003425		Lower half	32.5	32.5	32.5
S96T003426	149: 6	Upper half	31.5	30.8	31.15
S96T003427		Lower half	29.9	28.7	29.3
S96T003428	149: 7	Upper half	32.6	34.8	33.7
S96T003429		Lower half	26.7	27.3	27
S96T003430	149: 8	Upper half	29.2	< 30.1	< 29.65
S96T003431		Lower half	< 27.4	< 28.2	< 27.8
S96T003432	149: 9	Upper half	38.1	37.9	38
S96T003433		Lower half	< 25.1	30.7	< 27.9[QC:e]
S96T003620	149:10	Upper half	15.7	17.4	16.55
S96T003434	149:11	Upper half	28.7	< 23.4	< 26.05[QC:e]
S96T004759	Core 149	Solid composite	29.6	28.1	28.85
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 1,050	< 1,050	< 1,050
S96T003412		Lower half	< 1,020	< 1,030	< 1,025
S96T003619	149:10	Upper half	< 1,080	< 1,080	< 1,080
S96T003413	149:11	Upper half	< 1,010	< 1,010	< 1,010
S96T004758	Core 149	Solid composite	< 1,100	< 1,110	< 1,105
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	28.9	31.4	30.15

Table B2-46. Tank 241-S-111 Analytical Results: Neodymium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003361	149: 2	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003362	149: 3	Drainable liquid	< 40.1	< 40.1	< 40.1
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 47.6	< 48.4	< 48
S96T003422	149: 4	Upper half	< 38.5	< 37.6	< 38.05
S96T003423		Lower half	< 39.7	< 39.8	< 39.75
S96T003424	149: 5	Upper half	< 43	< 43.4	< 43.2
S96T003425		Lower half	< 37.5	< 38.4	< 37.95
S96T003426	149: 6	Upper half	< 35.8	< 34.3	< 35.05
S96T003427		Lower half	< 51.3	< 51.2	< 51.25
S96T003428	149: 7	Upper half	< 50.8	< 49.9	< 50.35
S96T003429		Lower half	< 52	< 51.7	< 51.85
S96T003430	149: 8	Upper half	< 56.8	< 60.3	< 58.55
S96T003431		Lower half	< 54.8	< 56.4	< 55.6
S96T003432	149: 9	Upper half	< 50.5	< 50.4	< 50.45
S96T003433		Lower half	< 50.2	< 50.2	< 50.2
S96T003620	149:10	Upper half	< 20.1	< 20.7	< 20.4
S96T003434	149:11	Upper half	< 47.3	< 46.7	< 47
S96T004759	Core 149	Solid composite	< 37.9	< 37.3	< 37.6
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 2,090	< 2,100	< 2,095
S96T003412		Lower half	< 2,040	< 2,060	< 2,050
S96T003619	149:10	Upper half	< 2,160	< 2,160	< 2,160
S96T003413	149:11	Upper half	< 2,010	< 2,030	< 2,020
S96T004758	Core 149	Solid composite	< 2,200	< 2,220	< 2,210
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 36.6	< 36.5	< 36.55

Table B2-47. Tank 241-S-111 Analytical Results: Nickel (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 8.02	< 8.02	< 8.02
S96T003361	149: 2	Drainable liquid	< 8.02	< 8.02	< 8.02
S96T003362	149: 3	Drainable liquid	< 8.02	< 8.02	< 8.02
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	51.9	52.3	52.1
S96T003422	149: 4	Upper half	85.7	86.9	86.3
S96T003423		Lower half	66.1	72.9	69.5
S96T003424	149: 5	Upper half	28.1	28	28.05
S96T003425		Lower half	33.9	32.6	33.25
S96T003426	149: 6	Upper half	34.5	27.6	31.05[QC:e]
S96T003427		Lower half	20.2	20.4	20.3
S96T003428	149: 7	Upper half	36.3	37.9	37.1
S96T003429		Lower half	20	20.2	20.1
S96T003430	149: 8	Upper half	21.3	24	22.65
S96T003431		Lower half	22.7	25.8	24.25
S96T003432	149: 9	Upper half	32.2	27.9	30.05
S96T003433		Lower half	< 10	32	< 21[QC:e]
S96T003620	149:10	Upper half	< 4.02	5.27	< 4.645[QC:e]
S96T003434	149:11	Upper half	32	< 9.35	< 20.675[QC:e]
S96T004759	Core 149	Solid composite	24.4	24.6	24.5
Solids: fusion[1]			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	841	19,000	9,920.5[QC:e]
S96T003412		Lower half	4,370	2,270	3,320[QC:e]
S96T003619	149:10	Upper half	5,830	4,990	5,410
S96T003413	149:11	Upper half	4,330	1,850	3,090[QC:e]
S96T004758	Core 149	Solid composite	1,490	1,270	1,380
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 7.32	< 7.31	< 7.315

Note:

[1]Fusion-digested nickel data should be used with caution because the samples were prepared in a nickel crucible.

Table B2-48. Tank 241-S-111 Analytical Results: Phosphorus (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	1,020	1,010	1,015
S96T003361	149: 2	Drainable liquid	1,060	1,030	1,045
S96T003362	149: 3	Drainable liquid	947	972	959.5
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	1,590	1,300	1,445[QC:e]
S96T003422	149: 4	Upper half	6,530	6,330	6,430
S96T003423		Lower half	6,100	5,310	5,705
S96T003424	149: 5	Upper half	1,430	889	1,159.5[QC:e]
S96T003425		Lower half	4,660	1,880	3,270[QC:e]
S96T003426	149: 6	Upper half	3,450	1,630	2,540[QC:e]
S96T003427		Lower half	316	283	299.5
S96T003428	149: 7	Upper half	2,190	2,020	2,105
S96T003429		Lower half	561	468	514.5
S96T003430	149: 8	Upper half	943	838	890.5
S96T003431		Lower half	7,530	3,240	5,385[QC:e]
S96T003432	149: 9	Upper half	3,780	4,420	4,100
S96T003433		Lower half	1,420	6,250	3,835[QC:e]
S96T003620	149:10	Upper half	390	342	366
S96T003434	149:11	Upper half	5,270	569	2,919.5[QC:e]
S96T004759	Core 149	Solid composite	883	4,770	2,826.5[QC:e]
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 4,190	< 4,200	< 4,195
S96T003412		Lower half	7,370	5,980	6,675[QC:e]
S96T003619	149:10	Upper half	< 4,310	< 4,330	< 4,320
S96T003413	149:11	Upper half	< 4,020	< 4,060	< 4,040
S96T004758	Core 149	Solid composite	< 4,390	< 4,440	< 4,415
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	2,450	2,160	2,305

Table B2-49. Tank 241-S-111 Analytical Results: Potassium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	1,590	1,490	1,540
S96T003361	149: 2	Drainable liquid	1,560	1,570	1,565
S96T003362	149: 3	Drainable liquid	1,490	1,570	1,530
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	1,050	1,080	1,065
S96T003422	149: 4	Upper half	847	822	834.5
S96T003423		Lower half	847	819	833
S96T003424	149: 5	Upper half	825	874	849.5
S96T003425		Lower half	778	835	806.5
S96T003426	149: 6	Upper half	842	785	813.5
S96T003427		Lower half	778	863	820.5
S96T003428	149: 7	Upper half	891	900	895.5
S96T003429		Lower half	784	753	768.5
S96T003430	149: 8	Upper half	730	763	746.5
S96T003431		Lower half	660	821	740.5[QC:e]
S96T003432	149: 9	Upper half	970	880	925
S96T003433		Lower half	329	751	540[QC:e]
S96T003620	149:10	Upper half	321	320	320.5
S96T003434	149:11	Upper half	637	453	545[QC:e]
S96T004759	Core 149	Solid composite	726	750	738
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	966	698	832[QC:e]

Table B2-50. Tank 241-S-111 Analytical Results: Samarium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			μg/mL	μg/mL	μg/mL
S96T003360	149: 1	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003361	149: 2	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003362	149: 3	Drainable liquid	< 40.1	< 40.1	< 40.1
Solids: acid digest			μg/g	μg/g	μg/g
S96T003420	149: 3	Whole	< 47.6	< 48.4	< 48
S96T003422	149: 4	Upper half	< 38.5	< 37.6	< 38.05
S96T003423		Lower half	< 39.7	< 39.8	< 39.75
S96T003424	149: 5	Upper half	< 43	< 43.4	< 43.2
S96T003425		Lower half	< 37.5	< 38.4	< 37.95
S96T003426	149: 6	Upper half	< 35.8	< 34.3	< 35.05
S96T003427		Lower half	< 51.3	< 51.2	< 51.25
S96T003428	149: 7	Upper half	< 50.8	< 49.9	< 50.35
S96T003429		Lower half	< 52	< 51.7	< 51.85
S96T003430	149: 8	Upper half	< 56.8	< 60.3	< 58.55
S96T003431		Lower half	< 54.8	< 56.4	< 55.6
S96T003432	149: 9	Upper half	< 50.5	< 50.4	< 50.45
S96T003433		Lower half	< 50.2	< 50.2	< 50.2
S96T003620	149:10	Upper half	< 20.1	< 20.7	< 20.4
S96T003434	149:11	Upper half	< 47.3	< 46.7	< 47
S96T004759	Core 149	Solid composite	< 37.9	< 37.3	< 37.6
Solids: fusion			μg/g	μg/g	μg/g
S96T003419	149: 9	Upper half	< 2,090	< 2,100	< 2,095
S96T003412		Lower half	< 2,040	< 2,060	< 2,050
S96T003619	149:10	Upper half	< 2,160	< 2,160	< 2,160
S96T003413	149:11	Upper half	< 2,010	< 2,030	< 2,020
S96T004758	Core 149	Solid composite	< 2,200	< 2,220	< 2,210
Solids: water digest			μg/g	μg/g	μg/g
S96T004761	Core 149	Solid composite	< 36.6	< 36.5	< 36.55

Table B2-51. Tank 241-S-111 Analytical Results: Selenium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 40.1	< 40.1	< 40.1
S96T003361	149: 2	Drainable liquid	41.7	41.7	41.7
S96T003362	149: 3	Drainable liquid	< 40.1	< 40.1	< 40.1
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 47.6	< 48.4	< 48
S96T003422	149: 4	Upper half	< 38.5	< 37.6	< 38.05
S96T003423		Lower half	< 39.7	< 39.8	< 39.75
S96T003424	149: 5	Upper half	< 43	< 43.4	< 43.2
S96T003425		Lower half	< 37.5	< 38.4	< 37.95
S96T003426	149: 6	Upper half	< 35.8	< 34.3	< 35.05
S96T003427		Lower half	< 51.3	< 51.2	< 51.25
S96T003428	149: 7	Upper half	< 50.8	< 49.9	< 50.35
S96T003429		Lower half	< 52	< 51.7	< 51.85
S96T003430	149: 8	Upper half	< 56.8	< 60.3	< 58.55
S96T003431		Lower half	< 54.8	< 56.4	< 55.6
S96T003432	149: 9	Upper half	< 50.5	< 50.4	< 50.45
S96T003433		Lower half	< 50.2	< 50.2	< 50.2
S96T003620	149:10	Upper half	< 20.1	< 20.7	< 20.4
S96T003434	149:11	Upper half	< 47.3	< 46.7	< 47
S96T004759	Core 149	Solid composite	< 37.9	< 37.3	< 37.6
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 2,090	< 2,100	< 2,095
S96T003412		Lower half	< 2,040	< 2,060	< 2,050
S96T003619	149:10	Upper half	< 2,160	< 2,160	< 2,160
S96T003413	149:11	Upper half	< 2,010	< 2,030	< 2,020
S96T004758	Core 149	Solid composite	< 2,200	< 2,220	< 2,210
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 36.6	< 36.5	< 36.55

Table B2-52. Tank 241-S-111 Analytical Results: Silicon (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	134	135	134.5
S96T003361	149: 2	Drainable liquid	134	133	133.5
S96T003362	149: 3	Drainable liquid	139	139	139
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	284	338	311[QC:b]
S96T003422	149: 4	Upper half	202	239	220.5[QC:b]
S96T003423		Lower half	242	204	223[QC:b]
S96T003424	149: 5	Upper half	214	329	271.5[QC:b,e]
S96T003425		Lower half	154	100	127[QC:b,e]
S96T003426	149: 6	Upper half	147	146	146.5[QC:b]
S96T003427		Lower half	90.1	99.5	94.8[QC:b]
S96T003428	149: 7	Upper half	100	99.3	99.65[QC:b]
S96T003429		Lower half	142	156	149[QC:b]
S96T003430	149: 8	Upper half	107	139	123[QC:b,e]
S96T003431		Lower half	130	102	116[QC:b,e]
S96T003432	149: 9	Upper half	84.2	70.6	77.4[QC:b]
S96T003433		Lower half	374	581	477.5[QC:b,e]
S96T003620	149:10	Upper half	304	465	384.5[QC:b,e]
S96T003434	149:11	Upper half	566	343	454.5[QC:b,e]
S96T004759	Core 149	Solid composite	719	482	600.5[QC:b,c,e]
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	1,120	< 1,050	< 1,085
S96T003412		Lower half	1,760	1,790	1,775
S96T003619	149:10	Upper half	< 1,080	< 1,080	< 1,080
S96T003413	149:11	Upper half	< 1,010	< 1,010	< 1,010
S96T004758	Core 149	Solid composite	1,450	< 1,110	< 1,280[QC:e]
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	483	389	436[QC:d,e]

Table B2-53. Tank 241-S-111 Analytical Results: Silver (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	15.5	15.3	15.4
S96T003361	149: 2	Drainable liquid	15.7	15.6	15.65
S96T003362	149: 3	Drainable liquid	14.8	14.8	14.8
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	12.3	10.8	11.55
S96T003422	149: 4	Upper half	13.7	14	13.85
S96T003423		Lower half	15	14.6	14.8
S96T003424	149: 5	Upper half	15.6	15.9	15.75
S96T003425		Lower half	14.9	14.8	14.85
S96T003426	149: 6	Upper half	15.6	15.2	15.4
S96T003427		Lower half	15.8	15.5	15.65[QC:a]
S96T003428	149: 7	Upper half	16.5	16.2	16.35[QC:a]
S96T003429		Lower half	16.1	16	16.05[QC:a]
S96T003430	149: 8	Upper half	16.2	16.1	16.15[QC:a]
S96T003431		Lower half	15.8	16.2	16[QC:a]
S96T003432	149: 9	Upper half	16.5	16.5	16.5[QC:a]
S96T003433		Lower half	< 5.02	7.09	< 6.055[QC:a,e]
S96T003620	149:10	Upper half	2.54	2.48	2.51
S96T003434	149:11	Upper half	5.83	< 4.67	< 5.25[QC:a,e]
S96T004759	Core 149	Solid composite	13	13.8	13.4[QC:a]
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 209	< 210	< 209.5
S96T003412		Lower half	< 204	< 206	< 205
S96T003619	149:10	Upper half	< 216	< 216	< 216
S96T003413	149:11	Upper half	< 201	< 203	< 202
S96T004758	Core 149	Solid composite	< 220	< 222	< 221[QC:c]
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	13.9	12.9	13.4

Table B2-54. Tank 241-S-111 Analytical Results: Sodium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	2.160E+05	2.170E+05	2.165E+05[QC:c]
S96T003361	149: 2	Drainable liquid	2.210E+05	2.210E+05	2.210E+05
S96T003362	149: 3	Drainable liquid	2.120E+05	2.120E+05	2.120E+05[QC:c]
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	1.580E+05	1.510E+05	1.545E+05
S96T003422	149: 4	Upper half	1.900E+05	1.890E+05	1.895E+05
S96T003423		Lower half	2.050E+05	1.970E+05	2.010E+05
S96T003424	149: 5	Upper half	2.180E+05	2.180E+05	2.180E+05
S96T003425		Lower half	2.110E+05	2.090E+05	2.100E+05
S96T003426	149: 6	Upper half	2.180E+05	2.150E+05	2.165E+05
S96T003427		Lower half	2.170E+05	2.190E+05	2.180E+05
S96T003428	149: 7	Upper half	2.300E+05	2.290E+05	2.295E+05
S96T003429		Lower half	2.250E+05	2.290E+05	2.270E+05
S96T003430	149: 8	Upper half	2.250E+05	2.330E+05	2.290E+05
S96T003431		Lower half	2.260E+05	2.250E+05	2.255E+05
S96T003432	149: 9	Upper half	2.290E+05	2.360E+05	2.325E+05
S96T003433		Lower half	45,500	97,500	71,500[QC:e]
S96T003620	149:10	Upper half	39,900	42,300	41,100[QC:b]
S96T003434	149:11	Upper half	89,900	40,700	65,300[QC:e]
S96T004759	Core 149	Solid composite	1.800E+05	1.890E+05	1.845E+05[QC:c]
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	2.890E+05	2.920E+05	2.905E+05
S96T003412		Lower half	1.530E+05	1.470E+05	1.500E+05
S96T003619	149:10	Upper half	56,200	56,400	56,300
S96T003413	149:11	Upper half	86,800	76,800	81,800
S96T004758	Core 149	Solid composite	2.160E+05	2.220E+05	2.190E+05[QC:d]
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	1.960E+05	1.860E+05	1.910E+05[QC:c]

Table B2-55. Tank 241-S-111 Analytical Results: Strontium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			μg/mL	μg/mL	μg/mL
S96T003360	149: 1	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003361	149: 2	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003362	149: 3	Drainable liquid	< 4.01	< 4.01	< 4.01
Solids: acid digest			μg/g	μg/g	μg/g
S96T003420	149: 3	Whole	< 4.76	< 4.84	< 4.8
S96T003422	149: 4	Upper half	4.53	4.58	4.555
S96T003423		Lower half	< 3.97	< 3.98	< 3.975
S96T003424	149: 5	Upper half	< 4.3	< 4.34	< 4.32
S96T003425		Lower half	< 3.75	< 3.84	< 3.795
S96T003426	149: 6	Upper half	< 3.58	< 3.43	< 3.505
S96T003427		Lower half	< 5.13	< 5.12	< 5.125
S96T003428	149: 7	Upper half	< 5.08	< 4.99	< 5.035
S96T003429		Lower half	< 5.2	< 5.17	< 5.185
S96T003430	149: 8	Upper half	< 5.68	< 6.03	< 5.855
S96T003431		Lower half	< 5.48	< 5.64	< 5.56
S96T003432	149: 9	Upper half	< 5.05	< 5.04	< 5.045
S96T003433		Lower half	< 5.02	< 5.02	< 5.02
S96T003620	149:10	Upper half	< 2.01	< 2.07	< 2.04
S96T003434	149:11	Upper half	< 4.73	< 4.67	< 4.7
S96T004759	Core 149	Solid composite	< 3.79	< 3.73	< 3.76
Solids: fusion			μg/g	μg/g	μg/g
S96T003419	149: 9	Upper half	< 209	< 210	< 209.5
S96T003412		Lower half	< 204	< 206	< 205
S96T003619	149:10	Upper half	< 216	< 216	< 216
S96T003413	149:11	Upper half	< 201	< 203	< 202
S96T004758	Core 149	Solid composite	< 220	< 222	< 221
Solids: water digest			μg/g	μg/g	μg/g
S96T004761	Core 149	Solid composite	< 3.66	< 3.65	< 3.655

Table B2-56. Tank 241-S-111 Analytical Results: Sulfur (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	1,510	1,510	1,510
S96T003361	149: 2	Drainable liquid	1,560	1,550	1,555
S96T003362	149: 3	Drainable liquid	1,560	1,570	1,565
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	1,850	1,850	1,850
S96T003422	149: 4	Upper half	8,910	9,150	9,030
S96T003423		Lower half	10,600	11,300	10,950
S96T003424	149: 5	Upper half	6,340	6,480	6,410
S96T003425		Lower half	7,350	7,630	7,490
S96T003426	149: 6	Upper half	6,440	5,920	6,180
S96T003427		Lower half	4,470	4,400	4,435
S96T003428	149: 7	Upper half	8,620	9,000	8,810
S96T003429		Lower half	4,970	5,120	5,045
S96T003430	149: 8	Upper half	5,320	5,810	5,565
S96T003431		Lower half	6,820	6,850	6,835
S96T003432	149: 9	Upper half	19,400	19,800	19,600
S96T003433		Lower half	70.2	1,340	705.1[QC:e]
S96T003620	149:10	Upper half	70	82.1	76.05
S96T003434	149:11	Upper half	1,240	63.9	651.95[QC:e]
S96T004759	Core 149	Solid composite	4,610	10,400	7,505[QC:e]
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	20,400	21,400	20,900
S96T003412		Lower half	< 2,040	< 2,060	< 2,050
S96T003619	149:10	Upper half	< 2,160	< 2,160	< 2,160
S96T003413	149:11	Upper half	< 2,010	< 2,030	< 2,020
S96T004758	Core 149	Solid composite	4,410	4,810	4,610
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	5,160	5,250	5,205

Table B2-57. Tank 241-S-111 Analytical Results: Thallium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 80.2	< 80.2	< 80.2
S96T003361	149: 2	Drainable liquid	< 80.2	< 80.2	< 80.2
S96T003362	149: 3	Drainable liquid	< 80.2	< 80.2	< 80.2
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 95.2	< 96.9	< 96.05
S96T003422	149: 4	Upper half	< 77	< 75.1	< 76.05
S96T003423		Lower half	< 79.3	< 79.6	< 79.45
S96T003424	149: 5	Upper half	< 86.1	< 86.8	< 86.45
S96T003425		Lower half	< 75	< 76.7	< 75.85
S96T003426	149: 6	Upper half	< 71.6	< 68.6	< 70.1
S96T003427		Lower half	< 103	< 102	< 102.5
S96T003428	149: 7	Upper half	< 102	< 99.8	< 100.9
S96T003429		Lower half	< 104	< 103	< 103.5
S96T003430	149: 8	Upper half	< 114	< 121	< 117.5
S96T003431		Lower half	< 110	< 113	< 111.5
S96T003432	149: 9	Upper half	< 101	< 101	< 101
S96T003433		Lower half	< 100	< 100	< 100
S96T003620	149:10	Upper half	< 40.2	< 41.3	< 40.75
S96T003434	149:11	Upper half	< 94.6	< 93.5	< 94.05
S96T004759	Core 149	Solid composite	< 75.8	< 74.6	< 75.2
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 4,190	< 4,200	< 4,195
S96T003412		Lower half	< 4,070	< 4,120	< 4,095
S96T003619	149:10	Upper half	< 4,310	< 4,330	< 4,320
S96T003413	149:11	Upper half	< 4,020	< 4,060	< 4,040
S96T004758	Core 149	Solid composite	< 4,390	< 4,440	< 4,415
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 73.2	< 73.1	< 73.15

Table B2-58. Tank 241-S-111 Analytical Results: Titanium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003361	149: 2	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003362	149: 3	Drainable liquid	< 4.01	< 4.01	< 4.01
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 4.76	< 4.84	< 4.8
S96T003422	149: 4	Upper half	< 3.85	< 3.76	< 3.805
S96T003423		Lower half	< 3.97	< 3.98	< 3.975
S96T003424	149: 5	Upper half	< 4.3	< 4.34	< 4.32
S96T003425		Lower half	< 3.75	< 3.84	< 3.795
S96T003426	149: 6	Upper half	< 3.58	< 3.43	< 3.505
S96T003427		Lower half	< 5.13	< 5.12	< 5.125
S96T003428	149: 7	Upper half	< 5.08	< 4.99	< 5.035
S96T003429		Lower half	< 5.2	< 5.17	< 5.185
S96T003430	149: 8	Upper half	< 5.68	< 6.03	< 5.855
S96T003431		Lower half	< 5.48	< 5.64	< 5.56
S96T003432	149: 9	Upper half	< 5.05	< 5.04	< 5.045
S96T003433		Lower half	< 5.02	< 5.02	< 5.02
S96T003620	149:10	Upper half	< 2.01	< 2.07	< 2.04
S96T003434	149:11	Upper half	< 4.73	< 4.67	< 4.7
S96T004759	Core 149	Solid composite	< 3.79	< 3.73	< 3.76
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 209	< 210	< 209.5
S96T003412		Lower half	< 204	< 206	< 205
S96T003619	149:10	Upper half	< 216	< 216	< 216
S96T003413	149:11	Upper half	< 201	< 203	< 202
S96T004758	Core 149	Solid composite	< 220	< 222	< 221
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 3.66	< 3.65	< 3.655

Table B2-59. Tank 241-S-111 Analytical Results: Total Uranium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 200	< 200	< 200
S96T003361	149: 2	Drainable liquid	< 200	< 200	< 200
S96T003362	149: 3	Drainable liquid	< 200	< 200	< 200
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 238	< 242	< 240
S96T003422	149: 4	Upper half	311	326	318.5
S96T003423		Lower half	273	291	282
S96T003424	149: 5	Upper half	< 215	< 217	< 216
S96T003425		Lower half	< 187	< 192	< 189.5
S96T003426	149: 6	Upper half	< 179	< 172	< 175.5
S96T003427		Lower half	< 257	< 256	< 256.5
S96T003428	149: 7	Upper half	< 254	< 250	< 252
S96T003429		Lower half	< 260	< 258	< 259
S96T003430	149: 8	Upper half	< 284	< 301	< 292.5
S96T003431		Lower half	282	< 282	< 282
S96T003432	149: 9	Upper half	345	353	349
S96T003433		Lower half	< 251	< 251	< 251
S96T003620	149:10	Upper half	< 101	< 103	< 102
S96T003434	149:11	Upper half	< 236	< 234	< 235
S96T004759	Core 149	Solid composite	< 189	224	< 206.5
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 10,500	< 10,500	< 10,500
S96T003412		Lower half	< 10,200	< 10,300	< 10,250
S96T003619	149:10	Upper half	< 10,800	< 10,800	< 10,800
S96T003413	149:11	Upper half	< 10,100	< 10,100	< 10,100
S96T004758	Core 149	Solid composite	< 11,000	< 11,100	< 11,050
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 183	< 183	< 183

Table B2-60. Tank 241-S-111 Analytical Results: Vanadium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 20.1	< 20.1	< 20.1
S96T003361	149: 2	Drainable liquid	< 20.1	< 20.1	< 20.1
S96T003362	149: 3	Drainable liquid	< 20.1	< 20.1	< 20.1
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	< 23.8	< 24.2	< 24
S96T003422	149: 4	Upper half	< 19.3	< 18.8	< 19.05
S96T003423		Lower half	< 19.8	< 19.9	< 19.85
S96T003424	149: 5	Upper half	< 21.5	< 21.7	< 21.6
S96T003425		Lower half	< 18.7	< 19.2	< 18.95
S96T003426	149: 6	Upper half	< 17.9	< 17.2	< 17.55
S96T003427		Lower half	< 25.7	< 25.6	< 25.65
S96T003428	149: 7	Upper half	< 25.4	< 25	< 25.2
S96T003429		Lower half	< 26	< 25.8	< 25.9
S96T003430	149: 8	Upper half	< 28.4	< 30.1	< 29.25
S96T003431		Lower half	< 27.4	< 28.2	< 27.8
S96T003432	149: 9	Upper half	< 25.3	< 25.2	< 25.25
S96T003433		Lower half	< 25.1	< 25.1	< 25.1
S96T003620	149:10	Upper half	< 10.1	< 10.3	< 10.2
S96T003434	149:11	Upper half	< 23.6	< 23.4	< 23.5
S96T004759	Core 149	Solid composite	< 18.9	< 18.7	< 18.8
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 1,050	< 1,050	< 1,050
S96T003412		Lower half	< 1,020	< 1,030	< 1,025
S96T003619	149:10	Upper half	< 1,080	< 1,080	< 1,080
S96T003413	149:11	Upper half	< 1,010	< 1,010	< 1,010
S96T004758	Core 149	Solid composite	< 1,100	< 1,110	< 1,105
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 18.3	< 18.3	< 18.3

Table B2-61. Tank 241-S-111 Analytical Results: Zinc (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	17.8	20.1	18.95
S96T003361	149: 2	Drainable liquid	23	18.2	20.6[QC:e]
S96T003362	149: 3	Drainable liquid	23.9	18.5	21.2[QC:e]
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	32.4	33.5	32.95
S96T003422	149: 4	Upper half	39	40.2	39.6
S96T003423		Lower half	38.7	36.5	37.6
S96T003424	149: 5	Upper half	23.4	22.6	23
S96T003425		Lower half	23.9	23.4	23.65
S96T003426	149: 6	Upper half	20.9	20.6	20.75
S96T003427		Lower half	23	22.8	22.9
S96T003428	149: 7	Upper half	28.3	25.2	26.75
S96T003429		Lower half	18.5	17.4	17.95
S96T003430	149: 8	Upper half	31.4	21.8	26.6[QC:e]
S96T003431		Lower half	18.8	16.8	17.8
S96T003432	149: 9	Upper half	20.8	23.7	22.25
S96T003433		Lower half	14.8	29.6	22.2[QC:e]
S96T003620	149:10	Upper half	14.8	18.2	16.5[QC:e]
S96T003434	149:11	Upper half	26.3	10.2	18.25[QC:e]
S96T004759	Core 149	Solid composite	20.3	26.2	23.25[QC:e]
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	535	552	543.5
S96T003412		Lower half	< 204	< 206	< 205
S96T003619	149:10	Upper half	558	1,650	1,104[QC:e]
S96T003413	149:11	Upper half	759	624	691.5
S96T004758	Core 149	Solid composite	< 220	< 222	< 221
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	8.52	< 3.65	< 6.085[QC:e]

Table B2-62. Tank 241-S-111 Analytical Results: Zirconium (ICP).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003360	149: 1	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003361	149: 2	Drainable liquid	< 4.01	< 4.01	< 4.01
S96T003362	149: 3	Drainable liquid	< 4.01	< 4.01	< 4.01
Solids: acid digest			µg/g	µg/g	µg/g
S96T003420	149: 3	Whole	4.87	5.12	4.995
S96T003422	149: 4	Upper half	7.06	7.41	7.235
S96T003423		Lower half	5.82	6.37	6.095
S96T003424	149: 5	Upper half	< 4.3	< 4.34	< 4.32
S96T003425		Lower half	< 3.75	< 3.84	< 3.795
S96T003426	149: 6	Upper half	3.65	3.5	3.575
S96T003427		Lower half	< 5.13	< 5.12	< 5.125
S96T003428	149: 7	Upper half	< 5.08	< 4.99	< 5.035
S96T003429		Lower half	< 5.2	< 5.17	< 5.185
S96T003430	149: 8	Upper half	< 5.68	< 6.03	< 5.855
S96T003431		Lower half	< 5.48	< 5.64	< 5.56
S96T003432	149: 9	Upper half	< 5.05	< 5.04	< 5.045
S96T003433		Lower half	< 5.02	< 5.02	< 5.02
S96T003620	149:10	Upper half	< 2.01	< 2.07	< 2.04
S96T003434	149:11	Upper half	4.85	< 4.67	< 4.76
S96T004759	Core 149	Solid composite	< 3.79	5.03	< 4.41[QC:e]
Solids: fusion			µg/g	µg/g	µg/g
S96T003419	149: 9	Upper half	< 209	< 210	< 209.5
S96T003412		Lower half	< 204	< 206	< 205
S96T003619	149:10	Upper half	< 216	< 216	< 216
S96T003413	149:11	Upper half	< 201	< 203	< 202
S96T004758	Core 149	Solid composite	< 220	< 222	< 221
Solids: water digest			µg/g	µg/g	µg/g
S96T004761	Core 149	Solid composite	< 3.66	< 3.65	< 3.655

B2.4.3.3 Total Uranium. Uranium was measured for a fusion-digested subsample of the core composite by kinetic phosphorescence. In this process, a complexing agent is added to the solution, which is then pulsed with a nitrogen laser. The phosphorescence decay of the uranium-phosphate complex is then measured. Quality control tests included standards, blanks, spikes, and duplicate analyses. Results are presented in Table B2-63.

Table B2-63. Tank 241-S-111 Analytical Results: Total Uranium (U).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Solids: fusion			µg/g	µg/g	µg/g
S96T004758	Core 149	Solid composite	187	196	191.5

B2.4.3.4 Free Hydroxide. Free hydroxide was measured on liquid samples by potentiometric titration. Interfering anions (e.g. carbonate) were precipitated prior to titration. Quality control tests included standard and blank analyses. Results are presented in Table B2-64.

Table B2-64. Tank 241-S-111 Analytical Results: Hydroxide (OH Direct).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			µg/mL	µg/mL	µg/mL
S96T003695	149: 1	Drainable liquid	38,900	40,600	39,750
S96T005969	149: 2	Drainable liquid	39,800	38,300	39,050
S96T003697	149: 3	Drainable liquid	42,300	42,500	42,400

B2.4.3.5 Hydrogen Potential (pH). The pH of the liquid samples was determined by a procedure that uses either a glass electrode in combination with a reference potential or a combination electrode. A reference standard was used for quality control. Results are presented in Table B2-65.

Table B2-65. Tank 241-S-111 Analytical Results: pH Measurement.

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			unitless	unitless	unitless
S96T003695	149: 1	Drainable liquid	13.07	13.11	13.09
S96T003696	149: 2	Drainable liquid	13.3	13.28	13.29
S96T003697	149: 3	Drainable liquid	13.36	13.38	13.37

B2.4.3.6 Ammonia. Ammonia was measured on the drainable liquid samples using a gas-sensing, ion selective electrode analyzer. Ammonia is quantified by a double standards addition method. Quality control parameters consisted of blank, standard, spike, and duplicate analyses. No duplicate result is reported for one of the three samples. Results are presented in Table B2-66.

Table B2-66. Tank 241-S-111 Analytical Results: Ammonia (Ion Selective Electrode).

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			μg/mL	μg/mL	μg/mL
S96T003695	149: 1	Drainable liquid	48.4	47.2	47.8
S96T005969	149: 2	Drainable liquid	68.4	67.9	68.15
S96T003697	149: 3	Drainable liquid	38.4	-	38.4

B2.4.4 Carbon Analyses

B2.4.4.1 Total Inorganic Carbon. Total inorganic carbon was performed on all drainable liquid and solid subsamples from core 149. Total inorganic carbon was required on the liquids according to the compatibility DQO, and was reported for the solids as well, because removal of TIC is a necessary step in the TOC procedure. Inorganic carbon is converted to CO_2 by acidification, heat, and sparging. The CO_2 is absorbed in an alcohol solution and titrated electrochemically. Quality control tests included standards, blanks, spikes, and duplicate analyses. Results are presented in Table B2-67.

Table B2-67. Tank 241-S-111 Analytical Results: Total Inorganic Carbon.

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Triplicate	Mean
Liquids			µg/g	µg/g	µg/g	µg/g
S96T003360	149: 1	Drainable liquid	3,144	3,262		3,203
S96T003361	149: 2	Drainable liquid	3,133	3,182		3,157
S96T003362	149: 3	Drainable liquid	3,310	2,963		3,136
Solids			µg/g	µg/g	µg/g	µg/g
S96T003346	149: 3	Whole	4,190	4,480	4,620	4,430
S96T003347	149: 4	Upper half	13,400	15,200		14,300
S96T003348		Lower half	17,200	19,200		18,200
S96T003349	149: 5	Upper half	9,270	8,640		8,955
S96T003350		Lower half	12,200	13,200		12,700
S96T003351	149: 6	Upper half	12,400	12,400		12,400
S96T003352		Lower half	8,700	8,660		8,680
S96T003353	149: 7	Upper half	16,600	16,000		16,300
S96T003354		Lower half	9,530	9,520		9,525
S96T003355	149: 8	Upper half	10,600	12,500	10,500	11,200
S96T003356		Lower half	10,600	11,600		11,100
S96T003357	149: 9	Upper half	24,800	23,200		24,000
S96T003358		Lower half	1,800	1,640		1,720
S96T003617	149:10	Upper half	1,240	1,060		1,150
S96T003359	149:11	Upper half	645	699	841	728.333
S96T004757	Core 149	Solid composite	9,940	9,610		9,775

B2.4.4.2 Total Organic Carbon. TOC was performed on all drainable liquid and solid subsamples. Following removal of TIC, TOC was converted CO_2 by hot acidic persulfate oxidation, absorbed in alcohol and titrated. Quality control tests included standards, blanks, spikes, and duplicate analyses. Results are presented in Table B2-68.

Table B2-68. Tank 241-S-111 Analytical Results: Total Organic Carbon.

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Triplicate	Mean
Liquids			µg/g	µg/g	µg/g	µg/g
S96T003360	149: 1	Drainable liquid	706	775		741
S96T003361	149: 2	Drainable liquid	754	754		754
S96T003362	149: 3	Drainable liquid	802	722		762
Solids			µg/g	µg/g	µg/g	µg/g
S96T003346	149: 3	Whole	2,350	3,960	4,110	3,473[QC:e]
S96T003347	149: 4	Upper half	3,090	4,240		3,665[QC:e]
S96T003348		Lower half	3,790	3,700		3,745
S96T003349	149: 5	Upper half	1,950	2,470		2,210[QC:e]
S96T003350		Lower half	2,140	2,370		2,255
S96T003351	149: 6	Upper half	2,690	2,650		2,670
S96T003352		Lower half	2,510	2,270		2,390
S96T003353	149: 7	Upper half	2,940	2,530		2,735
S96T003354		Lower half	1,740	1,730		1,735
S96T003355	149: 8	Upper half	2,120	1,580	1,690	1,796.67[QC:e]
S96T003356		Lower half	1,790	2,110		1,950
S96T003357	149: 9	Upper half	2,450	2,370		2,410
S96T003358		Lower half	1,570	1,360		1,465
S96T003617	149:10	Upper half	738	764		751
S96T003359	149:11	Upper half	687	404	514	535[QC:e]
S96T004757	Core 149	Solid composite	1,110	938		1,024

B2.4.5 Physical Analyses

B2.4.5.1 Bulk density. Bulk density was calculated on solids subsamples after centrifugation in a tared, graduated centrifuge cone. No quality control parameters were associated with this test. Results are presented in Table B2-69.

Table B2-69. Tank 241-S-111 Analytical Results: Bulk Density.

Sample Number	Sample Location	Sample Portion	Result
Solids			g/mL
S96T003316	149: 4	Lower half	1.65
S96T003322	149: 5	Lower half	1.69
S96T003323	149: 6	Lower half	1.78
S96T003324	149: 7	Lower half	1.69
S96T003325	149: 8	Lower half	1.58
S96T003344	149: 9	Lower half	1.87
S96T003613	149:10	Upper half	1.63
S96T003345	149:11	Upper half	1.7
S96T004755	Core 149	Solid composite	1.78

B2.4.5.2 Specific Gravity. The specific gravity of the liquid samples was calculated by weighing a known volume of the liquid, computing the density, and calculating the ratio of the density to the density of water. Quality control parameters consisted of standard and duplicate measurements. Results are presented in Table B2-70.

Table B2-70. Tank 241-S-111 Analytical Results: Specific Gravity.

Sample Number	Sample Location	Sample Portion	Result	Duplicate	Mean
Liquids			unitless	unitless	unitless
S96T003360	149: 1	Drainable liquid	1.362	1.372	1.367
S96T003361	149: 2	Drainable liquid	1.345	1.351	1.348
S96T003362	149: 3	Drainable liquid	1.372	1.35	1.361

B2.5 ASSESSMENT OF CHARACTERIZATION RESULTS

The purpose of this chapter is to discuss the overall quality and consistency of the current sampling results for tank 241-S-111, and to present the results of the calculation of an analytical-based inventory.

This section also evaluates sampling and analysis factors that may impact interpretation of the data. These factors are used to assess the overall quality and consistency of the data and to identify any limitations in the use of the data.

B2.5.1 Field Observations

Sample recovery was excellent for core 149, except for segment 10 (68 percent recovery). The hydraulic bottom detector activated 15 cm (6 in.) into the final segment (segment 11), and the sampler was retrieved from that position. The bottom detector activates at a specified downforce, and its activation is conservatively interpreted to mean that the bottom of the tank has been reached. It is possible that extremely hard waste, or debris under the riser, would cause the detector to activate. It is not uncommon to discover that the bottom of the tank is not at the elevation indicated by historical drawings. During drill string removal activities, elevated levels of flammable gas were detected in the drill string (up to 125 percent of the LFL). This indicates that flammable gas is being generated in the tank (flammability issues are addressed in Section B3).

Recovery was acceptable for the first two segments of core 150. The downforce limit was reached on segment 3, indicating that the waste is very hard or debris is under the riser. After five attempts to take this segment, the core was abandoned.

B2.5.2 Quality Control Assessment

The usual quality control assessment includes an evaluation of the appropriate standard recoveries, spike recoveries, duplicate analyses, and blanks that are performed in conjunction with the chemical analyses. All pertinent quality control tests were conducted on the 1995 auger samples, allowing a full assessment regarding the accuracy and precision of the data. The SAP (Conner 1996) established the specific criteria for all analytes.

The standard and spike recovery results provide an estimate of the accuracy of the analysis. If a standard or spike recovery is above or below the given criterion, the analytical results may be biased high or low, respectively. The precision is estimated by the RPD, which is defined as the absolute value of the difference between the primary and duplicate samples, divided by their mean, times one hundred.

Some total alpha results had high RPDs, but these results were near the detection limit and far below the action limit. The standard result for total beta was slightly above the QC limit. All QC criteria for ^{137}Cs were within the allowable limits. One DSC sample exhibited an RPD greater than the specified 30 percent; however, the sample result was very low. High RPDs were observed for some IC analytes (Cl, F, NO_3, oxalate, and PO_4). These were attributed to sample inhomogeneity (Steen 1996). High RPDs associated with some of the ICP analytes were also attributed to sample inhomogeneity. For a limited number of analytes, the spike (Al, Na) or standard (Si, Ag) recoveries were out of range. Serial dilutions were performed if the spike recovery was out of range.

Blank contamination was detected for some IC, ICP, and GEA analytes, as well as for TOC, TIC, and NH3. All contamination was far below the concentrations found in the samples, and did not affect the data quality.

In summary, the vast majority of the QC results were within the boundaries specified in the SAPs. The discrepancies mentioned here and footnoted in the data summary tables should impact neither the validity nor the use of the data.

B2.5.3 Data Consistency Checks

Comparisons of different analytical methods can help to assess the consistency and quality of the data. Several comparisons were possible with the data set provided by the two core samples. In addition, mass and charge balances were calculated to help assess the overall data consistency.

B2.5.3.1 Comparison of Results from Different Analytical Methods. The following data consistency checks compare the results from two different analytical methods. Good agreement between the two methods strengthens the credibility of both results, whereas poor agreement brings the reliability of the data into question.

The IC analyses for PO_4 and SO_4 can be compared with the respective P and S analyses by water digest-ICP. For the core composite sample, the PO_4 result by IC was 7,529 μg/g, and the P result by ICP-water digest, converted to PO_4, was 7,063 μg/g. The SO_4 result by IC was 16,200 μg/g, compared to the ICP-water digest result of 22,500 μg/g (as SO_4). These results indicate that the two methods are in reasonable agreement.

Another comparison that can be made is to compare the ^{137}Cs and ^{90}Sr results to the total beta. The ^{90}Sr concentration is doubled to account for the ^{90}Y daughter. Other beta emitters are expected to be much lower in activity. The only total beta result is on the core composite. The sum of the ^{137}Cs (112 μCi/g) and twice the ^{90}Sr concentration of 13.9 μCi/g is 140 μCi/g. This compares very well with the total beta result of 138 μCi/g, indicating that the beta and GEA analyses are in good agreement, and that ^{137}Cs and ^{90}Sr and their daughters are the principal sources of radioactivity for this tank.

The oxalate (by IC) and TOC (by persulfate oxidation) results can also be examined. Results for the core composite and segment level means for both solids and liquids are presented in Table B2-71. Oxalate (C_2O_4) concentrations were converted to carbon to allow the comparisons. No strong conclusions can be drawn, because the data do not exhibit a consistent relationship. Reasons for this might include other organic constituents in the waste, sample inhomogeneity, differences in preparation (oxalate was analyzed by IC after a water digest, and TOC was analyzed directly), or analytical bias in either or both of the methods.

Table B2-71. Comparison of Oxalate and TOC Data.

Analytical Boundary	Oxalate	Oxalate (as Carbon)	TOC	Oxalate Carbon/ TOC Ratio
Segment mean - liquids	2,510 μg/mL	685 μg/mL	1,410 μg/mL	0.49
Segment mean - solids	5,850 μg/g	1,600 μg/g	2,150 μg/g	0.74
Core composite	4,374 μg/g	1,190 μg/g	1,024 μg/g	1.17

B2.5.3.2 Mass and Charge Balance. The principal objective in performing mass and charge balances is to determine if the measurements are consistent. Mass and charge balances are presented for liquid segment-level averages and for the solid core composite.

B2.5.3.2.1 Mass and Charge Balance for Liquids. For the liquids, all species were assumed to be soluble. Because oxalate data were available, the TOC data were not used. Aluminum and chromium were assumed to be present as aluminate and dichromate, and TIC was assumed to be carbonate. The phosphate and sulfate data (by IC) were used, and the phosphorus and sulphur ICP data were ignored.

The concentrations of cationic species in Table B2-72, the anionic species in Table B2-73, and the percent water were ultimately used to calculate the mass balance.

The mass balance was calculated from the formula below. The factor 0.0001 is the conversion factor from $\mu g/g$ to weight percent. The density is used to convert from $\mu g/mL$ to $\mu g/g$.

Mass balance = % water + 0.0001 x {total analyte concentration} / density.

The total analyte concentration, taken from the cation and anion tables below, is 661,000 $\mu g/mL$. The average density of the liquid, used to convert to a mass basis, is 1.36 g/mL (from specific gravity data). The mean weight percent water is 53.2 percent, or 532,000 $\mu g/g$. The mass balance resulting from the equation above is 102 percent.

The following equations demonstrate the derivation of total cations and total anions:

<u>Total cations</u> (μeq/mL)

$= [Na^+]/23.0 + [K]/39.1 = 9,470$ μeq/mL

<u>Total anions</u> (μeq/mL)

$= [Al(OH)_4^-]/95.0 + [Cl^-]/35.5 + [Cr_2O_7^{2-}]*2/216.0 + [OH^-]/17.0 + [NO_3^-]/62.0 + [NO_2^-]/48.0 + [C_2O_4^{2-}]*2/88.0 + [PO4^{3-}]*3/95.0 + [SO4^{2-}]*2/96.0 + [CO_3^{2-}]*2/60.0$
$= 9,290$

The charge balance obtained by dividing the sum of the positive charge by the sum of the negative charge was 1.02.

In summary, the above calculations yield reasonable mass and charge balance values (close to 1.00 for charge balance and 100 percent for mass balance), indicating that the liquid analytical results are generally consistent.

Table B2-72. Cation Mass and Charge Data for Segment-Level Liquids.

Analyte	Concentration (μg/mL)	Assumed Species	Concentration of Assumed Species (μg/mL)	Charge/ Molecular Weight (μeq/μg)	Charge (μeq/mL)
Potassium	1,550	K^+	1,550	1/39.1	40
Sodium	217,000	Na^+	217,000	3.0	9,430
Total			219,000		9,470

Table B2-73. Anion Mass and Charge Data for Segment-Level Liquids.

Analyte	Concentration (μg/mL)	Assumed Species	Concentration of Assumed Species (μg/mL)	Charge/ Molecular Weight (μeq/μg)	Charge (μeq/mL)
Aluminum	25,100	$Al(OH)_4^-$	88,300	1/95.0	930
Chloride	6,270	Cl^-	6,270	1/35.5	177
Chromium	4,400	$Cr_2O_7^{2-}$	9,140	2/216.0	85
Hydroxide	40,400	OH^-	40,400	1/17.0	2,380
Nitrate	192,000	NO_3^-	192,000	1/62.0	3,100
Nitrite	66,600	NO_2^-	66,600	1/48.0	1,390
Oxalate	2,510	$C_2O_4^{2-}$	2,510	2/88.0	57
Phosphate	2,640	PO_4^{3-}	2,640	3/95.0	83
Sulfate	4,620	SO_4^{2-}	4,620	2/96.0	96
TIC	5,920	CO_3^{2-}	29,600	2/60.0	987
Total			442,000		9,290

B2.5.3.2.2 Mass and Charge Balance for Composite Solids. Except for sodium, all cations listed in Table B2-72 were assumed to be in their most common hydroxide or oxide form, and the concentrations of the assumed species were calculated stoichiometrically. Aluminum is split between 75 percent insoluble (Al_2O_3) and 25 percent water soluble [$Al(OH)_4$]. All cation concentrations were taken from the fusion digest ICP results. Only quantitated results were used. Because precipitates are neutral species, all positive charge was attributed to the sodium cation. The anions listed in Table B2-73 were assumed to be present as sodium salts and were expected to balance the positive charge exhibited by the cations. Phosphate and sulfate, as determined by IC, are assumed to be completely water soluble and appear only in the anion mass and charge calculations.

Mass and charge balances can be computed following the methods described above for liquids (except that a density correction is not necessary). The water concentration by TGA was 28.7 percent. The resulting mass balance is 102 percent and the charge balance (cations/anions) is 1.22. The mass balance is good, but the charge balance is reasonable. There is likely a significant amount of hydroxide in the solids. If the hydroxide were accounted for, the charge balance would improve. Cation and anion mass and charge data for the solid composite are presented in Tables B2-74 and B2-75.

Table B2-74. Cation Mass and Charge Data for Composite Solids.

Analyte	Concentration ($\mu g/g$)	Assumed Species	Concentration of Assumed Species ($\mu g/g$)	Charge/ Molecular Weight ($\mu eq/\mu g$)	Charge ($\mu eq/g$)
Aluminum	41,800	Al_2O_3	79,000	-	0
Chromium	4,180	$Cr(OH)_3$	8,280	-	0
Silicon	1,280	SiO_3	3,470	-	0
Sodium	219,000	Na^+	219,000	1/23.0	9,520
Total			306,000		9,520

Table B2-75. Anion Mass and Charge Data for Composite Solids.

Analyte	Concentration ($\mu g/g$)	Assumed Species	Concentration of Assumed Species ($\mu g/g$)	Charge/ Molecular Weight ($\mu eq/\mu g$)	Charge ($\mu eq/g$)
Chloride	2,750	Cl^-	2,750	1/35.5	77
Nitrate	267,000	NO_3^-	267,000	1/62.0	4,310
Nitrite	29,000	NO_2^-	29,000	1/48.0	604
Oxalate	4,370	$C_2O_4^{2-}$	4,370	2/88.0	100
Phosphate	7,530	PO_4^{3-}	7,530	3/95.0	237
Sulfate	16,200	SO_4^{2-}	16,200	2/96.0	338
TIC	9,780	CO_3^{2-}	48,900	2/60.0	1,630
Aluminum	14,000	$Al(OH)_4^-$	49,300	1/95.0	519
Total			425,000		7,820

B2.5.4 Mean Concentrations and Confidence Intervals

The following evaluation was performed on the analytical data from the samples from core 149 in tank 241-S-111.

Because an inventory estimate is needed without comparing it to a threshold value, two-sided 95 percent confidence intervals on the mean inventory are computed. For tank 241-S-111, this computation was done with both the composite-level and segment-level data. With segment-level data, the liquid sample data and solid sample data were analyzed separately.

The upper and lower limits (UL and LL) to a two-sided 95 percent confidence interval for the mean are

$$\hat{\mu} \pm t_{(df,0.025)} \times \hat{\sigma}_{\hat{\mu}}.$$

In these equations, $\hat{\mu}$ is the estimate of the mean concentration, $\hat{\sigma}_{\hat{\mu}}$ is the estimate of the standard deviation of the mean concentration, and $t_{(df,0.025)}$ is the quantile from Student's t distribution with df degrees of freedom for a two-sided 95 percent confidence interval.

The mean, $\hat{\mu}$, and the standard deviation, $\hat{\sigma}_{\hat{\mu}}$, were estimated using restricted maximum likelihood estimation (REML) methods. The degrees of freedom (df), for tank 241-S-111, is the number of segments sampled minus one for segment data and the number of observations minus one for composite data.

B2.5.4.1 Composite, Solid Segment, and Liquid Segment Means. The statistics in this section were based on analytical data from the most recent sampling event of tank 241-S-111. Analysis of variance (ANOVA) techniques were used to estimate the mean, and calculate confidence limits on the mean, for all analytes that had at least 50 percent of reported values above the detection limit. If at least 50 percent of the reported values were above the detection limit, all of the data was used in the computations. The detection limit was used as the value for nondetected results. No ANOVA estimates were computed for analytes with less than 50 percent detected values. Only arithmetic means were computed for these analytes.

The results given below are ANOVA estimates based on the core composite data from core 149 for tank 241-S-111. Estimates of the mean concentration, and confidence interval on the mean concentration, are given in Table B2-76. The LL to a 95 percent confidence interval can be negative. Because an actual concentration of less than zero is not possible, the lower limit is reported as zero, whenever this occurred.

The summary statistics given in Table B2-76 are for the concentration of analytes in the composite sample formed from the solid waste portion of segments 4 through 11 from core sample 149. Because these summary statistics are based on data from one composite sample, they reflect the composition of the core sample. The summary statistics do not reflect the analyte concentrations in the solid portion of the tank waste.

For each analyte in this table, the analytical data consist of only two values, the primary and duplicate result. Consequently, the standard deviation of the mean is a measure of the variability between the primary and duplicate result. The standard deviation of the mean does not include the spatial variability. Based on other core sample data, it has been shown that the spatial variability is the dominant term in the standard deviation of the mean (Jensen et al. 1995).

If it is assumed that there is no spatial variability, then the summary statistics in Table B2-76 are for the analyte concentrations in the solid portion of the waste. However, due to the incomplete core recovery for core 150, it is not appropriate to assume no spatial variability within the waste.

The degrees of freedom in Table B2-76 reflect the pair of observations from the composite sample from core 149.

Table B2-76. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
% water	%	2.87E+01	3.20E-01	1	2.46E+01	3.28E+01
DSC - dry	J/g	0	0	1	0	0
Alpha	μCi/g	1.29E-02	2.15E-03	1	0	4.02E-02
Am-241[1]	μCi/g	<6.93E-01	n/a	n/a	n/a	n/a
Beta	μCi/g	1.38E+02	4.00E+00	1	8.72E+01	1.89E+02
Co-60[1]	μCi/g	<1.62E-02	n/a	n/a	n/a	n/a
Cs-137	μCi/g	1.12E+02	5.15E+00	1	4.67E+01	1.78E+02
Eu-154[1]	μCi/g	<5.89E-02	n/a	n/a	n/a	n/a
Eu-155[1]	μCi/g	<2.62E-01	n/a	n/a	n/a	n/a
Sr-89/90	μCi/g	1.39E+01	7.00E-01	1	5.01E+00	2.28E+01
Bromide[1]	μg/g	<1.13E+03	n/a	n/a	n/a	n/a
Chloride	μg/g	2.75E+03	8.75E+01	1	1.64E+03	3.86E+03
Fluoride	μg/g	4.86E+02	4.48E+01	1	0	1.06E+03
ICP.a.Ag	μg/g	1.34E+01	4.00E-01	1	8.32E+00	1.85E+01
ICP.a.Al	μg/g	2.90E+04	3.05E+03	1	0	6.77E+04
ICP.a.As[1]	μg/g	<3.76E+01	n/a	n/a	n/a	n/a
ICP.a.B	μg/g	1.40E+02	1.15E+01	1	0	2.86E+02

Table B2-76. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.a.Ba[1]	μg/g	<1.88E+01	n/a	n/a	n/a	n/a
ICP.a.Be[1]	μg/g	<1.88E+00	n/a	n/a	n/a	n/a
ICP.a.Bi[2]	μg/g	3.79E+01	5.50E-01	1	3.09E+01	4.48E+01
ICP.a.Ca	μg/g	3.18E+02	9.45E+01	1	0	1.52E+03
ICP.a.Cd	μg/g	3.17E+00	6.50E-02	1	2.34E+00	3.99E+00
ICP.a.Ce[1]	μg/g	<3.76E+01	n/a	n/a	n/a	n/a
ICP.a.Co[1]	μg/g	<7.52E+00	n/a	n/a	n/a	n/a
ICP.a.Cr	μg/g	4.22E+03	7.00E+01	1	3.33E+03	5.11E+03
ICP.a.Cu[1]	μg/g	<3.76E+00	n/a	n/a	n/a	n/a
ICP.a.Fe	μg/g	9.38E+01	1.62E+01	1	0	3.00E+02
ICP.a.K	μg/g	7.38E+02	1.20E+01	1	5.86E+02	8.91E+02
ICP.a.La[1]	μg/g	<1.88E+01	n/a	n/a	n/a	n/a
ICP.a.Li[1]	μg/g	<3.76E+00	n/a	n/a	n/a	n/a
ICP.a.Mg[1]	μg/g	<3.76E+01	n/a	n/a	n/a	n/a
ICP.a.Mn	μg/g	4.91E+01	8.60E+00	1	0	1.58E+02
ICP.a.Mo	μg/g	2.89E+01	7.50E-01	1	1.93E+01	3.84E+01
ICP.a.Na	μg/g	1.85E+05	4.50E+03	1	1.27E+05	2.42E+05
ICP.a.Nd[1]	μg/g	<3.76E+01	n/a	n/a	n/a	n/a
ICP.a.Ni	μg/g	2.45E+01	1.00E-01	1	2.32E+01	2.58E+01
ICP.a.P	μg/g	2.83E+03	1.94E+03	1	0	2.75E+04
ICP.a.Pb[1]	μg/g	<3.76E+01	n/a	n/a	n/a	n/a
ICP.a.S	μg/g	7.51E+03	2.90E+03	1	0	4.43E+04
ICP.a.Sb[1]	μg/g	<2.26E+01	n/a	n/a	n/a	n/a
ICP.a.Se[1]	μg/g	<3.76E+01	n/a	n/a	n/a	n/a
ICP.a.Si	μg/g	6.01E+02	1.18E+02	1	0	2.11E+03
ICP.a.Sm[1]	μg/g	<3.76E+01	n/a	n/a	n/a	n/a

Table B2-76. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.a.Sr[1]	µg/g	<3.76E+00	n/a	n/a	n/a	n/a
ICP.a.Ti[1]	µg/g	<3.76E+00	n/a	n/a	n/a	n/a
ICP.a.Tl[1]	µg/g	<7.52E+01	n/a	n/a	n/a	n/a
ICP.a.U[2]	µg/g	2.07E+02	1.75E+01	1	0	4.29E+02
ICP.a.V[1]	µg/g	<1.88E+01	n/a	n/a	n/a	n/a
ICP.a.Zn	µg/g	2.33E+01	2.95E+00	1	0	6.07E+01
ICP.a.Zr[2]	µg/g	4.41E+00	6.20E-01	1	0	1.23E+01
ICP.f.Ag[1]	µg/g	<2.21E+02	n/a	n/a	n/a	n/a
ICP.f.Al	µg/g	5.58E+04	2.85E+03	1	1.95E+04	9.20E+04
ICP.f.As[1]	µg/g	<2.21E+03	n/a	n/a	n/a	n/a
ICP.f.B[1]	µg/g	<1.11E+03	n/a	n/a	n/a	n/a
ICP.f.Ba[1]	µg/g	<1.11E+03	n/a	n/a	n/a	n/a
ICP.f.Be[1]	µg/g	<1.11E+02	n/a	n/a	n/a	n/a
ICP.f.Bi[1]	µg/g	<2.21E+03	n/a	n/a	n/a	n/a
ICP.f.Ca[1]	µg/g	<2.21E+03	n/a	n/a	n/a	n/a
ICP.f.Cd[1]	µg/g	<1.11E+02	n/a	n/a	n/a	n/a
ICP.f.Ce[1]	µg/g	<2.21E+03	n/a	n/a	n/a	n/a
ICP.f.Co[1]	µg/g	<4.42E+02	n/a	n/a	n/a	n/a
ICP.f.Cr	µg/g	4.18E+03	6.00E+01	1	3.42E+03	4.94E+03
ICP.f.Cu[1]	µg/g	<2.21E+02	n/a	n/a	n/a	n/a
ICP.f.Fe[1]	µg/g	<1.11E+03	n/a	n/a	n/a	n/a
ICP.f.La[1]	µg/g	<1.11E+03	n/a	n/a	n/a	n/a
ICP.f.Li[1]	µg/g	<2.21E+02	n/a	n/a	n/a	n/a
ICP.f.Mg[1]	µg/g	<2.21E+03	n/a	n/a	n/a	n/a
ICP.f.Mn[1]	µg/g	<2.21E+02	n/a	n/a	n/a	n/a
ICP.f.Mo[1]	µg/g	<1.11E+03	n/a	n/a	n/a	n/a

Table B2-76. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.f.Na	µg/g	2.19E+05	3.00E+03	1	1.81E+05	2.57E+05
ICP.f.Nd[1]	µg/g	<2.21E+03	n/a	n/a	n/a	n/a
ICP.f.Ni	µg/g	1.38E+03	1.10E+02	1	0	2.78E+03
ICP.f.P[1]	µg/g	<4.42E+03	n/a	n/a	n/a	n/a
ICP.f.Pb[1]	µg/g	<2.21E+03	n/a	n/a	n/a	n/a
ICP.f.S	µg/g	4.61E+03	2.00E+02	1	2.07E+03	7.15E+03
ICP.f.Sb[1]	µg/g	<1.33E+03	n/a	n/a	n/a	n/a
ICP.f.Se[1]	µg/g	<2.21E+03	n/a	n/a	n/a	n/a
ICP.f.Si[2]	µg/g	1.28E+03	1.70E+02	1	0	3.44E+03
ICP.f.Sm[1]	µg/g	<2.21E+03	n/a	n/a	n/a	n/a
ICP.f.Sr[1]	µg/g	<2.21E+02	n/a	n/a	n/a	n/a
ICP.f.Ti[1]	µg/g	<2.21E+02	n/a	n/a	n/a	n/a
ICP.f.Tl[1]	µg/g	<4.42E+03	n/a	n/a	n/a	n/a
ICP.f.U[1]	µg/g	<1.11E+04	n/a	n/a	n/a	n/a
ICP.f.V[1]	µg/g	<1.11E+03	n/a	n/a	n/a	n/a
ICP.f.Zn[1]	µg/g	<2.21E+02	n/a	n/a	n/a	n/a
ICP.f.Zr[1]	µg/g	<2.21E+02	n/a	n/a	n/a	n/a
ICP.w.Ag	µg/g	1.34E+01	5.00E-01	1	7.05E+00	1.98E+01
ICP.w.Al	µg/g	1.48E+04	5.00E+02	1	8.45E+03	2.12E+04
ICP.w.As[1]	µg/g	<3.66E+01	n/a	n/a	n/a	n/a
ICP.w.B	µg/g	5.20E+02	7.90E+01	1	0	1.52E+03
ICP.w.Ba[1]	µg/g	<1.83E+01	n/a	n/a	n/a	n/a
ICP.w.Be[1]	µg/g	<1.83E+00	n/a	n/a	n/a	n/a
ICP.w.Bi[1]	µg/g	<3.66E+01	n/a	n/a	n/a	n/a
ICP.w.Ca[1]	µg/g	<3.66E+01	n/a	n/a	n/a	n/a
ICP.w.Cd[1]	µg/g	<1.83E+00	n/a	n/a	n/a	n/a

Table B2-76. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.w.Ce[1]	μg/g	<3.66E+01	n/a	n/a	n/a	n/a
ICP.w.Co[1]	μg/g	<7.32E+00	n/a	n/a	n/a	n/a
ICP.w.Cr	μg/g	1.03E+03	3.95E+01	1	5.29E+02	1.53E+03
ICP.w.Cu[1]	μg/g	<3.66E+00	n/a	n/a	n/a	n/a
ICP.w.Fe[1]	μg/g	<1.83E+01	n/a	n/a	n/a	n/a
ICP.w.K	μg/g	8.32E+02	1.34E+02	1	0	2.54E+03
ICP.w.La[1]	μg/g	<1.83E+01	n/a	n/a	n/a	n/a
ICP.w.Li[1]	μg/g	<3.66E+00	n/a	n/a	n/a	n/a
ICP.w.Mg[1]	μg/g	<3.66E+01	n/a	n/a	n/a	n/a
ICP.w.Mn[1]	μg/g	<3.66E+00	n/a	n/a	n/a	n/a
ICP.w.Mo	μg/g	3.02E+01	1.25E+00	1	1.43E+01	4.60E+01
ICP.w.Na	μg/g	1.91E+05	5.00E+03	1	1.28E+05	2.55E+05
ICP.w.Nd[1]	μg/g	<3.66E+01	n/a	n/a	n/a	n/a
ICP.w.Ni[1]	μg/g	<7.32E+00	n/a	n/a	n/a	n/a
ICP.w.P	μg/g	2.31E+03	1.45E+02	1	4.63E+02	4.15E+03
ICP.w.Pb[1]	μg/g	<3.66E+01	n/a	n/a	n/a	n/a
ICP.w.S	μg/g	5.21E+03	4.50E+01	1	4.63E+03	5.78E+03
ICP.w.Sb[1]	μg/g	<2.20E+01	n/a	n/a	n/a	n/a
ICP.w.Se[1]	μg/g	<3.66E+01	n/a	n/a	n/a	n/a
ICP.w.Si	μg/g	4.36E+02	4.70E+01	1	0	1.03E+03
ICP.w.Sm[1]	μg/g	<3.66E+01	n/a	n/a	n/a	n/a
ICP.w.Sr[1]	μg/g	<3.66E+00	n/a	n/a	n/a	n/a
ICP.w.Ti[1]	μg/g	<3.66E+00	n/a	n/a	n/a	n/a
ICP.w.Tl[1]	μg/g	<7.32E+01	n/a	n/a	n/a	n/a
ICP.w.U[1]	μg/g	<1.83E+02	n/a	n/a	n/a	n/a
ICP.w.V[1]	μg/g	<1.83E+01	n/a	n/a	n/a	n/a

Table B2-76. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Composite Sample Data. (6 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.w.Zn[2]	μg/g	6.09E+00	2.43E+00	1	0	3.70E+01
ICP.w.Zr[1]	μg/g	<3.66E+00	n/a	n/a	n/a	n/a
Nitrate	μg/g	2.67E+05	1.69E+04	1	5.22E+04	4.82E+05
Nitrite	μg/g	2.90E+04	9.90E+02	1	1.64E+04	4.16E+04
Oxalate	μg/g	4.37E+03	2.94E+02	1	6.44E+02	8.10E+03
Phosphate	μg/g	7.53E+03	5.49E+02	1	5.53E+02	1.45E+04
Sulfate	μg/g	1.62E+04	8.50E+01	1	1.51E+04	1.73E+04
TIC	μg/g	9.78E+03	1.65E+02	1	7.68E+03	1.19E+04
TOC*	μg/g	1.02E+03	8.60E+01	1	0	2.12E+03
Uranium	μg/g	1.92E+02	4.50E+00	1	1.34E+02	2.49E+02
Bulk density[3]	----	1.78E+00	n/a	n/a	n/a	n/a

Notes:

n/a = not applicable
* = wet basis

[1]More than 50 percent of the analytical results were less than values; therefore, confidence intervals were not computed.

[2]Some less than values are in the analytical results.

[3]No duplicates were sampled; therefore, a confidence interval could not be constructed.

In addition to core composite data, segment level data from tank 241-S-111 were also available from core 149. The liquid sample data and solid sample data were analyzed separately. Mean concentration estimates, along with 95 percent confidence intervals on the mean, are given in Table B2-77 for the solid segment sample data and Table B2-78 for the liquid segment sample data.

The summary statistics given in Table B2-77 are for the concentration of analytes in the segment samples formed from the whole segment and half segment samples of the solid waste portion of segments 4 through 11 from core sample 149. Because these summary statistics are based on data from one core sample, they reflect the composition of the core sample. The summary statistics do not reflect the analyte concentrations in the solid portion of the tank waste.

For each analyte in this table, the analytical data consist of only two values, the primary and duplicate result, from each of the half segments (segments 3 through 9) and each of the whole segments (segments 10 and 11). Consequently, the standard deviation of the mean is a measure of the variability between the primary and duplicate result and the vertical variability between the segments. The standard deviation of the mean does not include the horizontal spatial variability.

If it is assumed there is no horizontal spatial variability, then the summary statistics in Table B2-76 are for the analyte concentrations in the solid portion of the waste. However, because of the incomplete core recovery for core 150, it is not appropriate to assume no horizontal spatial variability within the waste. The degrees of freedom in Table B2-77 reflect the number of segments within core 149.

The summary statistics given in Table B2-78 are for the concentration of analytes in the segment samples formed from the drainable liquid portion of segments 1 through 3 from core sample 149. Because these summary statistics are based on data from one core sample, they reflect the composition of the core sample. The summary statistics do not reflect the analyte concentrations in the liquid portion of the tank waste.

For each analyte in this table, the analytical data consist of only two values, the primary and duplicate result, from each of the liquid portions of segment 1, 2 and 3. Consequently, the standard deviation of the mean is a measure of the variability between the primary and duplicate result and the vertical variability between the three segments. The standard deviation of the mean does not include the horizontal spatial variability.

If it is assumed there is no horizontal spatial variability, then the summary statistics in Table B2-76 are for the analyte concentrations in the liquid portion of the waste. However, because of the incomplete core recovery for core 150, it is not appropriate to assume no horizontal spatial variability within the waste. The degrees of freedom in Table B2-78 reflect the number of segments with drainable liquid from core 149.

Table B2-77. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Solid Segment Sample Data. (4 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
% Water	%	2.85E+01	4.19E+00	8	1.88E+01	3.81E+01
DSC-Dry	J/g	3.09E+01	1.46E+01	8	0	6.46E+01
Am-241[1]	μCi/g	<1.05E+00	n/a	n/a	n/a	n/a
Alpha[2]	μCi/g	2.86E-02	7.06E-03	8	1.23E-02	4.48E-02
Co-60[1]	μCi/g	<5.75E-02	n/a	n/a	n/a	n/a
Cs-137	μCi/g	1.12E+02	9.01E+00	8	9.09E+01	1.33E+02
Eu-154[1]	μCi/g	<1.85E-01	n/a	n/a	n/a	n/a
Eu-155[1]	μCi/g	<5.07E-01	n/a	n/a	n/a	n/a
Bromide[1]	μg/g	<1.00E+03	n/a	n/a	n/a	n/a
Chloride	μg/g	2.98E+03	1.52E+02	8	2.63E+03	3.33E+03
Fluoride[2]	μg/g	7.27E+02	2.26E+02	8	2.06E+02	1.25E+03
ICP.a.Ag[2]	μg/g	1.24E+01	1.52E+00	8	8.92E+00	1.59E+01
ICP.a.Al	μg/g	2.17E+04	4.45E+03	8	1.14E+04	3.20E+04
ICP.a.As[1]	μg/g	<4.52E+01	n/a	n/a	n/a	n/a
ICP.a.B	μg/g	1.04E+02	9.64E+00	8	8.14E+01	1.26E+02
ICP.a.Ba[1]	μg/g	<2.26E+01	n/a	n/a	n/a	n/a
ICP.a.Be[1]	μg/g	<2.26E+00	n/a	n/a	n/a	n/a
ICP.a.Bi[1]	μg/g	<5.62E+01	n/a	n/a	n/a	n/a
ICP.a.Ca	μg/g	1.62E+02	1.36E+01	8	1.30E+02	1.93E+02
ICP.a.Cd[2]	μg/g	5.50E+00	1.30E+00	8	2.50E+00	8.50E+00
ICP.a.Ce[1]	μg/g	<4.52E+01	n/a	n/a	n/a	n/a
ICP.a.Co[1]	μg/g	<9.04E+00	n/a	n/a	n/a	n/a
ICP.a.Cr	μg/g	5.64E+03	1.07E+03	8	3.17E+03	8.11E+03
ICP.a.Cu[1]	μg/g	<4.52E+00	n/a	n/a	n/a	n/a
ICP.a.Fe	μg/g	1.91E+02	7.38E+01	8	2.09E+01	3.62E+02
ICP.a.K	μg/g	7.67E+02	4.65E+01	8	6.60E+02	8.74E+02

Table B2-77. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Solid Segment Sample Data. (4 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.a.La[1]	μg/g	<2.26E+01	n/a	n/a	n/a	n/a
ICP.a.Li[1]	μg/g	<4.52E+00	n/a	n/a	n/a	n/a
ICP.a.Mg[1]	μg/g	<4.52E+01	n/a	n/a	n/a	n/a
ICP.a.Mn[2]	μg/g	6.08E+01	1.30E+01	8	3.08E+01	9.09E+01
ICP.a.Mo[2]	μg/g	3.07E+01	1.48E+00	8	2.72E+01	3.41E+01
ICP.a.Na	μg/g	1.74E+05	2.11E+04	8	1.25E+05	2.22E+05
ICP.a.Nd[1]	μg/g	<4.52E+01	n/a	n/a	n/a	n/a
ICP.a.Ni[2]	μg/g	3.23E+01	7.02E+00	8	1.61E+01	4.85E+01
ICP.a.P	μg/g	2.65E+03	5.94E+02	8	1.28E+03	4.02E+03
ICP.a.Pb[1]	μg/g	<4.54E+01	n/a	n/a	n/a	n/a
ICP.a.S	μg/g	6.24E+03	1.27E+03	8	3.30E+03	9.18E+03
ICP.a.Sb[1]	μg/g	<2.71E+01	n/a	n/a	n/a	n/a
ICP.a.Se[1]	μg/g	<4.52E+01	n/a	n/a	n/a	n/a
ICP.a.Si	μg/g	2.18E+02	3.44E+01	8	1.39E+02	2.98E+02
ICP.a.Sm[1]	μg/g	<4.52E+01	n/a	n/a	n/a	n/a
ICP.a.Sr[1]	μg/g	<4.57E+00	n/a	n/a	n/a	n/a
ICP.a.Ti[1]	μg/g	<4.52E+00	n/a	n/a	n/a	n/a
ICP.a.Tl[1]	μg/g	<9.04E+01	n/a	n/a	n/a	n/a
ICP.a.U[1]	μg/g	<2.47E+02	n/a	n/a	n/a	n/a
ICP.a.V[1]	μg/g	<2.26E+01	n/a	n/a	n/a	n/a
ICP.a.Zn	μg/g	2.43E+01	2.32E+00	8	1.90E+01	2.97E+01
ICP.a.Zr[1]	μg/g	<4.91E+00	n/a	n/a	n/a	n/a
ICP.f.Ag[1]#	μg/g	<2.08E+02	n/a	n/a	n/a	n/a
ICP.f.Al#	μg/g	1.82E+05	5.94E+04	2	0	4.38E+05
ICP.f.As[1]#	μg/g	<2.08E+03	n/a	n/a	n/a	n/a
ICP.f.B[1]#	μg/g	<1.04E+03	n/a	n/a	n/a	n/a

Table B2-77. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Solid Segment Sample Data. (4 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.f.Ba[1]#	μg/g	<1.04E+03	n/a	n/a	n/a	n/a
ICP.f.Be[1]#	μg/g	<1.04E+02	n/a	n/a	n/a	n/a
ICP.f.Bi[1]#	μg/g	<2.08E+03	n/a	n/a	n/a	n/a
ICP.f.Ca[1]#	μg/g	<2.08E+03	n/a	n/a	n/a	n/a
ICP.f.Cd[1]#	μg/g	<1.04E+02	n/a	n/a	n/a	n/a
ICP.f.Ce[1]#	μg/g	<2.08E+03	n/a	n/a	n/a	n/a
ICP.f.Co[1]#	μg/g	<4.16E+02	n/a	n/a	n/a	n/a
ICP.f.Cr#	μg/g	3.81E+03	1.56E+03	2	0	1.05E+04
ICP.f.Cu[1]#	μg/g	<2.08E+02	n/a	n/a	n/a	n/a
ICP.f.Fe[1]#	μg/g	<1.04E+03	n/a	n/a	n/a	n/a
ICP.f.La[1]#	μg/g	<1.04E+03	n/a	n/a	n/a	n/a
ICP.f.Li[1]#	μg/g	<2.08E+02	n/a	n/a	n/a	n/a
ICP.f.Mg[1]#	μg/g	<2.08E+03	n/a	n/a	n/a	n/a
ICP.f.Mn[1]#	μg/g	<2.17E+02	n/a	n/a	n/a	n/a
ICP.f.Mo[1]#	μg/g	<1.04E+03	n/a	n/a	n/a	n/a
ICP.f.Na#	μg/g	1.35E+05	5.68E+04	2	0	3.79E+05
ICP.f.Nd[1]#	μg/g	<2.08E+03	n/a	n/a	n/a	n/a
ICP.f.Ni#	μg/g	5.44E+03	2.03E+03	2	0	1.42E+04
ICP.f.P[1]#	μg/g	<4.81E+03	n/a	n/a	n/a	n/a
ICP.f.Pb[1]#	μg/g	<2.08E+03	n/a	n/a	n/a	n/a
ICP.f.S[1]#	μg/g	<6.78E+03	n/a	n/a	n/a	n/a
ICP.f.Sb[1]#	μg/g	<1.25E+03	n/a	n/a	n/a	n/a
ICP.f.Se[1]#	μg/g	<2.08E+03	n/a	n/a	n/a	n/a
ICP.f.Si[1]#	μg/g	<1.24E+03	n/a	n/a	n/a	n/a
ICP.f.Sm[1]#	μg/g	<2.08E+03	n/a	n/a	n/a	n/a
ICP.f.Sr[1]#	μg/g	<2.08E+02	n/a	n/a	n/a	n/a

Table B2-77. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Solid Segment Sample Data. (4 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
ICP.f.Ti[1]#	μg/g	<2.08E+02	n/a	n/a	n/a	n/a
ICP.f.Tl[1]#	μg/g	<4.16E+03	n/a	n/a	n/a	n/a
ICP.f.U[1]#	μg/g	<1.04E+04	n/a	n/a	n/a	n/a
ICP.f.V[1]#	μg/g	<1.04E+03	n/a	n/a	n/a	n/a
ICP.f.Zn[2]#	μg/g	6.92E+02	2.17E+02	2	0	1.63E+03
ICP.f.Zr[1]#	μg/g	<2.08E+02	n/a	n/a	n/a	n/a
Nitrate	μg/g	1.94E+05	4.46E+04	8	9.12E+04	2.97E+05
Nitrite	μg/g	3.02E+04	2.22E+03	8	2.51E+04	3.53E+04
Oxalate[2]	μg/g	5.85E+03	1.28E+03	8	2.90E+03	8.80E+03
Phosphate[2]	μg/g	8.83E+03	2.06E+03	8	4.08E+03	1.36E+04
Sulfate[2]	μg/g	1.93E+04	3.88E+03	8	1.03E+04	2.82E+04
TIC	μg/g	1.04E+04	1.69E+03	8	6.45E+03	1.43E+04
TOC	μg/g	2.15E+03	3.46E+02	8	1.36E+03	2.95E+03
Bulk density[3]	----	1.70E+00	3.20E-02	7	1.62E+00	1.77E+00

Notes:

n/a = not applicable
* = wet basis
# = For fusion digest samples, only the bottom three segments were sampled from core.

[1]More than 50 percent of the analytical results were less than values; therefore, confidence intervals were not computed.

[2]Some less than values are in the analytical results.

[3]No duplicates were sampled; therefore, a confidence interval could not be constructed.

Table B2-78. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Liquid Segment Sample Data. (3 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
% Water	%	5.32E+01	1.94E-01	2	5.23E+01	5.40E+01
DSC - dry	J/g	0	0	2	0	0
Alpha[1]	µCi/mL	<8.01E-03	n/a	n/a	n/a	n/a
Am-241[2]	µCi/mL	2.55E-04	7.89E-05	2	0	5.95E-04
Am241.GEA[1]	µCi/mL	<6.39E-01	n/a	n/a	n/a	n/a
Co-60[1]	µCi/mL	<7.79E-03	n/a	n/a	n/a	n/a
Cs-137	µCi/mL	2.43E+02	6.51E+00	2	2.15E+02	2.71E+02
Eu-154[1]	µCi/mL	<4.94E-02	n/a	n/a	n/a	n/a
Eu-155[1]	µCi/mL	<2.71E-01	n/a	n/a	n/a	n/a
Pu-239/240[1]	µCi/mL	<9.84E-05	n/a	n/a	n/a	n/a
Sr-89/90	µCi/mL	4.31E-01	3.87E-01	2	0	2.10E+00
Ag	µg/mL	1.53E+01	2.52E-01	2	1.42E+01	1.64E+01
Al	µg/mL	2.51E+04	2.85E+02	2	2.39E+04	2.64E+04
As[1]	µg/mL	<4.01E+01	n/a	n/a	n/a	n/a
B	µg/mL	7.79E+01	1.15E+00	2	7.30E+01	8.29E+01
Ba[1]	µg/mL	<2.01E+01	n/a	n/a	n/a	n/a
Be[1]	µg/mL	<2.00E+00	n/a	n/a	n/a	n/a
Bi[1]	µg/mL	<4.01E+01	n/a	n/a	n/a	n/a
Bromide[1]	µg/mL	<1.03E+03	n/a	n/a	n/a	n/a
Ca[1]	µg/mL	<4.01E+01	n/a	n/a	n/a	n/a
Cd[1]	µg/mL	<2.00E+00	n/a	n/a	n/a	n/a
Ce[1]	µg/mL	<4.01E+01	n/a	n/a	n/a	n/a
Chloride	µg/mL	6.27E+03	3.52E+02	2	4.76E+03	7.79E+03
Co[1]	µg/mL	<8.02E+00	n/a	n/a	n/a	n/a
Cr	µg/mL	4.40E+03	6.41E+01	2	4.12E+03	4.67E+03
Cu[1]	µg/mL	<4.01E+00	n/a	n/a	n/a	n/a

Table B2-78. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Liquid Segment Sample Data. (3 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
Fe[1]	μg/mL	<2.01E+01	n/a	n/a	n/a	n/a
Fluoride[1]	μg/mL	<1.05E+02	n/a	n/a	n/a	n/a
Hydroxide	μg/mL	4.04E+04	1.02E+03	2	3.60E+04	4.48E+04
K	μg/mL	1.55E+03	1.78E+01	2	1.47E+03	1.62E+03
La[1]	μg/mL	<2.01E+01	n/a	n/a	n/a	n/a
Li[1]	μg/mL	<4.01E+00	n/a	n/a	n/a	n/a
Mg[1]	μg/mL	<4.01E+01	n/a	n/a	n/a	n/a
Mn[1]	μg/mL	<4.01E+00	n/a	n/a	n/a	n/a
Mo	μg/mL	6.51E+01	6.51E-01	2	6.23E+01	6.79E+01
Na	μg/mL	2.17E+05	2.60E+03	2	2.05E+05	2.28E+05
Nd[1]	μg/mL	<4.01E+01	n/a	n/a	n/a	n/a
NH3	μg/mL	5.15E+01	8.78E+00	2	1.37E+01	8.92E+01
Ni[1]	μg/mL	<8.02E+00	n/a	n/a	n/a	n/a
Nitrate	μg/mL	1.92E+05	8.17E+03	2	1.57E+05	2.28E+05
Nitrite	μg/mL	6.66E+04	4.29E+03	2	4.82E+04	8.51E+04
Oxalate[2]	μg/mL	2.51E+03	1.69E+03	2	0	9.79E+03
P	μg/mL	1.01E+03	2.50E+01	2	8.99E+02	1.11E+03
Pb[1]	μg/mL	<4.01E+01	n/a	n/a	n/a	n/a
Phosphate[2]	μg/mL	2.64E+03	3.42E+02	2	1.17E+03	4.11E+03
S	μg/mL	1.54E+03	1.69E+01	2	1.47E+03	1.62E+03
Sb[1]	μg/mL	<2.41E+01	n/a	n/a	n/a	n/a
Se[1]	μg/mL	<4.06E+01	n/a	n/a	n/a	n/a
Si	μg/mL	1.36E+02	1.69E+00	2	1.28E+02	1.43E+02
Sm[1]	μg/mL	<4.01E+01	n/a	n/a	n/a	n/a
Sr[1]	μg/mL	<4.01E+00	n/a	n/a	n/a	n/a
Sulfate	μg/mL	4.62E+03	1.73E+02	2	3.87E+03	5.36E+03

Table B2-78. 95 Percent Two-Sided Confidence Interval for the Mean Concentration for Liquid Segment Sample Data. (3 sheets)

Analyte	Units	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	df	LL	UL
Ti[1]	μg/mL	<4.01E+00	n/a	n/a	n/a	n/a
TIC	μg/mL	5.92E+03	9.23E+01	2	5.52E+03	6.32E+03
Tl[1]	μg/mL	<8.02E+01	n/a	n/a	n/a	n/a
TOC*	μg/mL	1.41E+03	2.67E+01	2	1.29E+03	1.52E+03
U[1]	μg/mL	<2.00E+02	n/a	n/a	n/a	n/a
V[1]	μg/mL	<2.01E+01	n/a	n/a	n/a	n/a
Zn	μg/mL	2.03E+01	1.07E+00	2	1.57E+01	2.48E+01
Zr[1]	μg/mL	<4.01E+00	n/a	n/a	n/a	n/a
SpG	----	1.36E+00	5.61E-03	2	1.34E+00	1.38E+00
pH	pH	1.33E+01	8.33E-02	2	1.29E+01	1.36E+01

Notes:

n/a = not applicable
* = wet basis

[1]More than 50 percent of the analytical results were less than values; therefore, confidence intervals were not computed.

[2]Some less than values are in the analytical results.

B2.5.4.2 Analysis of Variance Models. A statistical model is needed to account for the spatial and measurement variability in $\hat{\sigma}_{\hat{\mu}}$. This cannot be done using an ordinary standard deviation of the data (Snedecor and Cochran 1980).

The statistical model fit to the composite sample data is

$$Y_i = \mu + A_i,$$

$$i = 1, \ldots, a$$

where

Y_i = laboratory results from the i^{th} duplicate in the tank

μ = the grand mean

A_i = the effect of the i^{th} duplicate

a = the number of analytical results

A_i is assumed to be uncorrelated and normally distributed with mean zero and variance $\sigma^2(A)$. Estimate of $\sigma^2(A)$ were obtained using REML techniques. This method, applied to variance component estimation, is described in Harville (1977). The statistical results were obtained using the statistical analysis package S-PLUS[1] (Statistical Sciences, Inc. 1993).

The statistical model fit to the liquid segment sample data is

$$Y_{ij} = \mu + S_i + A_{ij},$$

$$i=1,\ldots,a,\ j= 1,\ldots,b_i,$$

where

Y_{ij} = laboratory results from the j^{th} duplicate from the i^{th} segment in the tank

μ = the grand mean

S_i = the effect of the i^{th} segment

A_{ij} = the effect of the j^{th} analytical result from the i^{th} segment

a = the number of segments

b_i = the number of analytical results from the i^{th} segment

The variable S_i is assumed to be a random effect. This variable and A_{ij} are assumed to be uncorrelated and normally distributed with means zero and variances $\sigma^2(S)$ and $\sigma^2(A)$, respectively. Estimates of $\sigma^2(S)$ and $\sigma^2(A)$ were obtained using the REML method. This method, applied to variance component estimation, is described in Harville (1977). The statistical results were obtained using the statistical analysis package S-PLUS™ (Statistical Sciences, Inc. 1993).

[1]Trademark of Statistical Sciences, Inc., Seattle, Washington.

The statistical model fit to the solid segment sample data is

$$Y_{ijk} = \mu + S_i + L_{ij} + A_{ijk},$$

$$i=1,\ldots,a,\ j= 1,\ldots,b_i,\ k=1,\ldots,c_{ij},$$

where

Y_{ijk} = laboratory results from the k^{th} duplicate in the j^{th} location in the i^{th} segment in the tank,

μ = the grand mean

S_i = the effect of the i^{th} segment

L_{ij} = the effect of the j^{th} location from the i^{th} segment

A_{ijk} = the effect of the k^{th} analytical result in the j^{th} location in the i^{th} segment

a = the number of segments

b_i = the number of locations in the i^{th} segment

c_{ij} = the number of analytical results from the j^{th} location in the i^{th} segment.

The variable S_i and L_{ij} are assumed to be random effects. These variables and A_{ijk} are assumed to be uncorrelated and normally distributed with means zero and variances $\sigma^2(S)$, $\sigma^2(L)$, and $\sigma^2(A)$, respectively. Estimates of $\sigma^2(S)$, $\sigma^2(L)$, and $\sigma^2(A)$ were obtained using the REML method. This method, applied to variance component estimation, is described in Harville (1977). The statistical results were obtained using statistical analysis package S-PLUS™ (Statistical Sciences, Inc. 1993).

B2.5.4.3 Inventory. After the sample means are calculated for the tank for each analyte, the sampling based inventory may be calculated. Because the analyte concentrations above are presented in terms of a mass basis concentration, the total mass of waste in the tank is needed to estimate inventories. The total mass of waste is derived from the tank volume (from surveillance) and the estimated tank solids density (from analytical data). The tank volume for solids is 2,220 kL (596 kgal) and the tank volume for liquids is 38 kL (Hanlon 1996). The density used for this estimate is 1.36 g/mL for liquid segment sample data, and 1.78 g/mL for composite sample data. The tank inventory is presented as the "best-basis inventory" in Appendix D.

B3.0 VAPOR SAMPLING RESULTS

B3.1 STANDARD HYDROGEN MONITORING SYSTEM

Because tank 241-S-111 is on the Flammable Gas Watch List (Public Law 101-510), installation of an SHMS system was required by Milestone M-40-10 of the Tri-Party Agreement (Ecology et al. 1996). Vapor from the tank is continuously sampled from a probe inserted well into the tank headspace. The detector is a Whittaker[2] electrochemical cell that is hydrogen specific. The cell generates an electrical signal proportional to the volume percent hydrogen concentration. The system is calibrated quarterly. The SHMS also has a grab sample station that allows two 75-cm^3 vapor samples to be taken simultaneously from the gas stream, isolated, and transported to a laboratory for analysis (Wilkins et al. 1996).

The SHMS provided data for tank 241-S-111 over the period August 21, 1995 to January 19, 1997. The highest hydrogen concentration detected was 1,270 ppm on December 14, 1995. This result is well below the action limit of 6,250 ppm (Wilkins et al. 1996).

B3.2 VAPOR GRAB SAMPLES

Several vapor grab samples were taken via the SHMS in July and August, 1995. The bottles were analyzed by mass spectrometry for the presence of hydrogen, methane, and nitrous oxide. The results are presented in Table B3-1. Results were taken from Wilkins et al. (1996).

Table B3-1. Results from Vapor Grab Samples from Tank 241-S-111.

Sample Date	H_2 (ppm)	CH_4 (ppm)	N_2O (ppm)
July 11, 1995	53	< 5	< 10
July 14, 1995	16	< 5	< 10
July 17, 1995	< 5	< 5	< 10
August 3, 1995	77	2	17
August 8, 1995	5	2	< 5
August 7, 1995	210	3	38

[2]Whittaker is a trademark of Whittaker Corp.,

B3.3 HEATED VAPOR PROBE

Tank 241-S-111 headspace gas and vapor samples were collected and analyzed to help determine the potential risks of fugitive emissions to tank farm workers. Tank 241-S-111 was vapor sampled in accordance with *Data Quality Objectives for Generic In-Tank Health and Safety Issue Resolution* (Osborne et al. 1995). The results and discussion provided here are derived from the vapor characterization report (Huckaby and Bratzel 1995).

Headspace gas and vapor samples were collected from tank 241-S-111 using the vapor sampling system (VSS) on March 21, 1995. The tank headspace temperature was determined to be 23 °C (73 °F). Air from the tank 241-S-111 headspace was withdrawn from a single elevation via a 6.7-m (22-ft)-long heated sampling probe mounted in riser 14, and transferred via heated tubing to the VSS sampling manifold.

B3.3.1 Inorganic Gases and Vapors

Analytical results of sorbent trap and SUMMA[3] canister tank air samples for selected inorganic gases and vapors are given in Table B3-2 in parts per million by volume (ppmv) in dry air. The concentration of water vapor given in Table 3-1 has been adjusted to tank conditions at the time of sampling (Huckaby and Bratzel 1995).

B3.3.1.1 Ammonia, Hydrogen, and Nitrous Oxide. Six sorbent trap samples from tank 241-S-111 indicated an average ammonia concentration of 122 ppmv. This concentration of ammonia is typical of waste tanks that have been sampled. Given the LFL of ammonia in air is about 15 percent by volume (vol%), the measured 122 ppmv corresponds to about 0.08 percent of the LFL, and does not contribute appreciably to tank's headspace flammability.

The concentration of hydrogen in tank 241-S-111 was determined to be 391 ppmv. Hydrogen in the waste tanks is of concern as a fuel. Given that the LFL for hydrogen in air is about 4 vol%, a 391-ppmv hydrogen concentration in tank 241-S-111 corresponds to about 1 percent of the LFL for hydrogen. At this level, hydrogen is not a flammability concern in tank 241-S-111.

The average nitrous oxide concentration reported by Pacific Northwest National Laboratory (PNNL) for the three SUMMA™ canister samples was 48 ppmv. Under the proper conditions, nitrous oxide can serve as an oxidizer to support combustion. However, Cashdollar et al. (1992) found that nitrous oxide had no significant effect on the flammability of hydrogen and air mixtures for hydrogen concentrations less than 20 vol%, and that "small

[3]SUMMA is a trademark of Molectrics, Inc., Cleveland, Ohio.

amounts of nitrous oxide (relative to air) do not appear to have much effect on the flammability." Their results suggest the measured nitrous oxide concentration is much too low to have a significant effect on the flammability of the tank 241-S-111 headspace.

Table B3-2. Tank S-111 Inorganic Gas and Vapor Data.[1]

Compound	CAS Number	Sample Type	Number of Samples	Average (ppmv)	Standard Deviation (ppmv)	RSD (%)
Ammonia, NH_3	7664-41-7	Sorbent trap	6	122	3	2.5
Carbon dioxide, CO_2	124-38-9	SUMMA™	3	< 23	--	--
Carbon monoxide, CO	630-08-0	SUMMA™	3	< 23	--	--
Hydrogen, H_2	1333-74-0	SUMMA™	3	391	1	0.3
Nitric oxide, NO	10102-43-9	Sorbent trap	6	≤ 0.07	--	--
Nitrogen dioxide, NO_2	10102-44-0	Sorbent trap	6	≤ 0.01	--	--
Nitrous oxide, N_2O	10024-97-2	SUMMA™	3	48	2	4
Water vapor, H_2O	7732-18-5	Sorbent trap	6	15,300 (11.0 mg/L)	200 (0.1 mg/L)	1.2

Notes:

CAS = Chemical Abstract Service
RSD = relative standard deviation. Burnum (1995) specifies the RSD should be less than 25 percent.

[1]Huckaby and Bratzel (1995)

B3.3.1.2 Discussion of Inorganic Gases and Vapors. Except for water vapor, the most abundant waste constituents in the tank 241-S-111 headspace are hydrogen, ammonia, and nitrous oxide. These have been detected in most of the tank headspaces that have been sampled, and are usually the dominant gaseous species. None of the inorganic headspace constituents exceeded the specified flammability nor industrial hygiene notification limits (Homi 1995).

B3.3.2 Organic Vapors

Organic vapors in the tank 241-S-111 headspace were sampled using SUMMA™ canisters, which were analyzed by PNNL, and triple sorbent traps (TSTs), which were analyzed by Oak Ridge National Laboratory (ORNL). Both PNNL and ORNL used a gas chromatograph (GC) equipped with a mass spectrometer (MS) detector to separate, identify, and quantitate the analytes.

SUMMA™ sample results should be considered to be the primary organic vapor data for tank 241-S-111. Analyses by ORNL of TST samples from this and other waste tanks generally agree with, support, and augment the SUMMA™ sample results. However, because certain quality assurance requirements were not satisfied by ORNL, the quality assurance assessment of ORNL by Hendrickson (1995) should be reviewed before results unique to the TST samples are used for decision making.

B3.3.2.1 Positively Identified Organic Compounds. Positive identification of organic analytes using the methods employed by PNNL and ORNL involves matching the GC retention times and MS data from a sample with that obtained from the analysis of standards. The concentration of an analyte in the sample is said to be quantitatively measured if the response of the GC/MS has been established at several known concentrations of that analyte (i.e., the GC/MS has been calibrated for that analyte), and the MS response to the analyte in the sample is between the lowest and highest responses to the known concentrations (i.e., the analyte is within the calibration range).

ORNL and PNNL were assigned different lists of organic compounds, or target analytes, to positively identify and measure quantitatively. The ORNL target analyte list was derived from a review of the tank 241-C-103 headspace constituents by a panel of toxicology experts (Mahlum et al. 1994). The PNNL target analyte list included 39 compounds in the Environmental Protection Agency (EPA) task order 14 (TO-14) method, which are primarily halocarbons and common industrial solvents (EPA 1988), plus 14 analytes selected mainly from the toxicology panel's review of vapor data from tank 241-C-103.

Table B3-3 lists the organic compounds positively identified and quantitated in SUMMA™ samples. SUMMA™ analyses were performed according to a modified version of the TO-14 methodology, except for methane analysis, which was analyzed with the inorganic gases (Klinger et al. 1995). Only 2 of the 39 TO-14 target analytes and 5 of the 14 additional target analytes were measured to be above the 0.005 ppmv detection limit of the analyses. Averages reported are from analyses of three SUMMA™ canister samples.

Jenkins et al. (1995) reports the positive identification of 25 of 27 target analytes in TST samples. Dibutyl butylphosphonate and tributyl phosphate were the only TST target analytes not detected, though dichloromethane was detected in only 1 TST sample. The average concentrations of the two detected and quantitated detected target analytes (ethanenitrile, and toluene), from the analysis of 4 TSTs, are given in Table B3-4. Despite calibration of the instrument over about a 20-fold concentration range, the concentrations of 18 compounds were determined to be below the lower calibration limit of the analyses in at least one of the TST samples. These analytes are listed in Table B3-5. Data in Table B3-5 should not be considered quantitative and may not be accurate to within ±30 percent as specified by Burnum (1995).

Both PNNL and ORNL report target analyte concentrations in ppmv of analyte in dry air. To correct for the measured water vapor content of tank 241-S-111 and obtain concentrations in ppmv of analytes in moist tank air, multiply the dry-air ppmv concentrations by 0.985.

Table B3-3. Tank S-111 Quantitatively Measured Organic Compounds in SUMMA™ Samples.[1]

Compound	CAS Number	Average[2] (ppmv)	Standard Deviation[3] (ppmv)	RSD[4] (%)
Ethanenitrile (acetonitrile)	75-05-8	0.011	0.001	8
Propanone (acetone)	67-64-1	0.15	0.02	16
Trichlorofluoromethane	75-69-4	0.021	0.003	12
1-Propanol[5]	71-23-8	0.0080	0.0050	--
2-Butanone	78-93-3	0.010	0.002	20
Tetrahydrofuran	109-99-9	0.017	0.0001	1
Toluene	108-88-3	0.022	0.001	4
Methane	74-82-8	< 23	--	--
		0.75	mg/m^3	

Notes:

[1]Huckaby and Bratzel (1995)

[2]Average of three samples

[3]When the analyte was detected in only two samples, the entry is the relative difference (i.e., their difference divided by 2).

[4]Burnum (1995) specifies the RSD should be less than 25 percent.

[5] Detected in only 2 samples

Table B3-4. Tank S-111 Quantitatively Measured Organic Compounds in TST Samples.[1]

Compound	CAS Number	Average (ppmv)	Standard[2] Deviation (ppmv)	RSD (%)
Ethanenitrile (acetonitrile)	75-05-8	0.021	0.004	17
Toluene	108-88-3	0.018	0.0004	2

Notes:

[1]Huckaby and Bratzel (1995)
[2]Average of 4 TST samples: 1 was a 1-liter sample and 3 were 4-liter samples.
[3]Burnum (1995) specifies the RSD should be less than 25 percent.

Table B3-5. Tank S-111 Positively Identified Organic Compounds in TST Samples.[1] (2 sheets)

Compound	CAS[2] Number	Average[3] (ppmv)	Standard Deviation (ppmv)	RSD[4] (%)
1,1-dichloroethene (vinylidene chloride)	75-35-4	0.00017	0.00001	5
Dichloromethane (methylene chloride)	75-09-2	0.00010	--	--
n-Propanenitrile	107-12-0	0.0015	0.0003	21
n-Hexane	110-54-3	0.0031	0.0002	6
Benzene	71-43-2	0.0030	0.0001	3
n-Butanenitrile	109-74-0	0.0035	0.0003	9
n-Heptane	142-82-5	0.0018	0.0001	4
2-Hexanone	591-78-6	0.00072	0.00001	2
n-Octane	111-65-9	0.00066	0.00001	2
n-Hexanenitrile	628-73-9	0.00017	0.00001	4
2-Heptanone	110-43-0	0.00072	0.00004	5
n-Nonane	111-84-2	0.00039	0.00001	1
n-Heptanenitrile	629-08-3	0.000081	0.000006	7
2-Octanone	111-13-7	0.00017	0.00001	4

Table B3-5. Tank S-111 Positively Identified Organic Compounds in TST Samples.[1] (2 sheets)

Compound	CAS[2] Number	Average[3] (ppmv)	Standard Deviation (ppmv)	RSD[4] (%)
n-Decane	124-18-5	0.00034	0.00002	7
n-Undecane	1120-21-4	0.00024	0.00001	3
n-Dodecane	112-40-3	0.00012	0.00002	12
n-Tridecane	629-50-5	0.00020	0.00002	7

Notes:

[1]Huckaby and Bratzel (1995)

[2]Results in this table are not quantitative (as defined in Section 4.1) because measured values in at least one of the samples are outside instrument calibration limits.

[3]Average of 4 TST samples: 1 was a 1-liter sample and 3 were 4-liter samples.

[4]Burnum (1995) specifies the RSD should be less than 25 percent.

The most abundant analytes detected were propanone and 1-butanol, both of which were measured to have average concentrations of between 0.05 and 0.2 ppmv in the tank 241-S-111 samples. At the reported concentrations, the target analytes do not individually or collectively represent a flammability hazard.

B3.3.2.2 Tentatively Identified Organic Compounds. In addition to the target analytes, the ORNL and PNNL analytical procedures allow the tentative identification of other organic compounds. Tentative identification of analytes was performed by comparing the MS molecular fragmentation patterns with a library of known MS fragmentation patterns. This method allows an organic analyte to be identified (with reasonable certainty) as an alkane, a ketone, an aldehyde, etc., and may also determine its molecular weight. The method usually does not, however, allow the unambiguous identification of structural isomers, and this ambiguity increases with analyte molecular weight. Using these methods, many analytes can be tentatively identified with reasonable confidence without having to inject standards of each into the GC/MS to determine their GC retention times or specific MS patterns. Tentatively identified compounds are presented in Huckaby and Bratzel (1995).

B3.3.2.3 Discussion of Organic Compounds. A convenient way to consider the organic compounds detected is to separate them into 2 categories: 1) Organic compounds added to tank 241-S-111 as waste that are still evaporating; and 2) organic compounds that have been generated by reactions of the original waste.

The first category encompasses all organic compounds that were placed into the tank as waste, and includes the semivolatile straight-chain alkanes, which were used as diluents of tributyl phosphate in various plutonium extraction processes. These alkanes (i.e., n-undecane, n-dodecane, n-tridecane, and n-tetradecane) are often referred to in Hanford Site literature as the normal paraffinic hydrocarbons (NPHs). Though NPHs are positively identified in tank 241-S-111, their concentrations are very low compared to other NPH-rich tanks.

Tributyl phosphate was probably also added to the tank as waste. The fact that tributyl phosphate was not detected in the tank 241-S-111 samples does not preclude its existence in either the waste or the headspace of tank 241-S-111. Informal tests by ORNL indicate that tributyl phosphate is adsorbed by the glass fiber filters used during sampling to protect the samples from radiolytic particulate contamination. This adsorption results in loss of tributyl phosphate from the sampled air, and an underestimation of its actual concentration in the tank headspace. The prominence of 1-butanol, a known hydrolysis product of tributyl phosphate, in the tank 241-S-111 organic vapor samples suggests that small amounts of tributyl phosphate are present in the waste.

The second category includes all organic compounds that have been generated via radiolytic and chemical reactions of the waste. The majority of organic compounds detected fall into this category, including the alcohols, aldehydes, ketones, nitriles, and volatile alkanes, all of which have been associated with the degradation of the NPHs.

On the basis of concentrations, alcohols are the dominant organic compounds in the tank 241-S-111 headspace. Methanol, ethanol, and 1-propanol account for about 20 percent of the total estimated concentration of organic compounds in TST samples, and about 46 percent of the total estimated concentration of organic compounds in SUMMA™ canister samples. The abundance of volatile alcohols is common to most other waste tanks located in the 200 West area of the Hanford Site.

The total organic vapor concentration of tank 241-S-111 was estimated by Jenkins et al. (1995) to be about 1.5 mg/m^3 from the analysis of four TST samples by GC/MS. A similar summation of organic compounds measured in SUMMA™ samples from tank 241-S-111 provides an estimated total organic vapor concentration of 2.0 mg/m^3. This disagreement is largely due to the different estimated concentrations of the dominant alcohols in the two sample types.

In summary, the organic vapor concentrations in tank 241-S-111 are relatively low. The organic vapors in tank 241-S-111 indicate that small quantities of the NPH process diluent and tributyl phosphate may be present in the waste. As with most other 200 West Area waste tanks that have been sampled, the concentrations of short-chain alcohols are higher in tank 241-S-111 than in waste tanks with higher NPH vapor concentrations. Conversely, ketones and aldehydes are less abundant in tank 241-S-111 than in NPH-rich waste tanks. None of the organic constituents exceeded the specified industrial hygiene notification limits (Homi 1995).

B4.0 HISTORICAL SAMPLE RESULTS

Historically, single-shell tank waste samples were analyzed to characterize the supernatant, sludge, and/or saltcake in each tank. Data have been compiled for the samples obtained from the late 1950s to the present for single-shell tanks in the 200 East and West areas of the Hanford Site. Analyses of several samples for tank 241-S-111 were obtained from historical records. The sample reports were made from July 20, 1971 to September 18, 1980.

B4.1 DESCRIPTION OF 1980 SAMPLE DATA

Sample data were reported on September 18, 1980 (Bratzel 1980). These data were from the 1978 core sampling event, but adjusted to correct inconsistencies in the data reported earlier. Water soluble and water insoluble data are provided, along with some physical property data. The data apparently were averaged for this report, and are provided in Table B4-1.

B4.2 DESCRIPTION OF 1978 SAMPLE

An eight-segment core sample from tank 241-S-111 was delivered to the laboratory between February 2, 1978 and June 27, 1978, and analytical results were reported on August 25, 1978 (Horton 1978). Three samplers were empty, and another was contaminated with drilling mud. A total of 144.8 cm (57 in.) of saltcake was recovered, along with 87 mL of supernatant. Two of the segments were combined prior to analysis. The supernatant was reportedly all from sample 1009-C, but two tables of data are given. The salt samples were described as "yellowish green in color, with variable crystal sizes," and were approximately 95 percent water soluble. Analytical results for all samples are in Tables B4-2a through B4-2e. Particle size analyses were also reported, but are not included in this TCR.

B4.3 DESCRIPTION OF 1976 SAMPLE

A sample was received on December 27, 1976 and reported on February 28, 1977 (Horton 1977). The salt sample was described as being damp, fine, dark green crystals. This sample is described as a "surface sample" in a later report (Horton 1978), and photographs indicate that it was a core sample.

Analyses were made by dissolving about 6 g of crystals in water and diluting the solution. The solids were about 90 percent soluble in water. Solids insoluble in water were dissolved in concentrated HCl and the resultant solution diluted. Analytical results are in Table B4-3.

B4.4 DESCRIPTION OF DECEMBER 1974 SAMPLE

Sample T-8141 was reported on December 16, 1974 (Wheeler 1974). Neither the date of sample retrieval nor date of analysis is given. A description of the technique or procedure used to obtain the sample or information concerning the sampled riser or sample depth was unavailable. The sample was described as yellowish green, and 100 percent solids. Analytical results are in Table B4-4. Analytical methods in use during this time period are described by Babad and Buckingham (1974).

B4.5 DESCRIPTION OF AUGUST 1974 SAMPLE

A sample was reported on August 23, 1974 (Horton and Buckingham 1974). The sampling date was August 2, 1974 (Babad and Buckingham 1974). The sample was taken to see whether the salts produced in a recent evaporator run were deliquescent. A description of the technique or procedure used to obtain the sample or information concerning the sampled riser or sample depth was not provided. Results for both salt and "mother liquor" (supernatant) were reported, along with a graph of the weight gain of the salt when placed in a 75 percent relative humidity chamber. The graph indicates that the salt was very hygroscopic, gaining 40 percent in weight over 15 days. The salt deliquesced after 6 days (gaining 22 percent in weight over that time). Analytical results are in Table B4-5. Analytical methods in use during this time period are described by Babad and Buckingham (1974).

B4.6 DESCRIPTION OF MAY 1974 SAMPLE

A sample was reported on May 29, 1974 (Buckingham 1974). Neither the date of sample retrieval nor date of analysis is given. Information concerning the sampled riser or sample depth was not provided. The tank was being evaluated as a potential saltcake receiver. The letter states that the sample was taken with a "sludge sample tube," perhaps indicating a core sample. The sample was described as gray in color, and consisting of approximately 60 percent Al_2O_3. These observations and other data are consistent with the sludge recovered from the 1996 core sample (segments 10-11 of core 149). Analytical results for the May 1974 sample are in Table B4-6. Analytical methods in use during this time period are described by Babad and Buckingham (1974).

B4.7 DESCRIPTION OF 1971 SAMPLE

A sample was reported on July 20, 1971 (Puryear 1971a). More complete data was provided in a second letter (Puryear 1971b). Neither the date of sample retrieval nor date of analysis is given. A description of the technique or procedure used to obtain the sample or information concerning the sampled riser or sample depth was not provided. The tank waste was sampled and analyzed as a feed candidate for the 242-S Evaporator. Analytical results are given in Table B4-7. A one-liter sample was also processed through the laboratory evaporator, but no results are provided in the letter reports.

Table B4-1. Tank 241-S-111 Data Reported September 18, 1980.[1,2] (2 sheets)

Chemical Analysis		
Component	**Water-Soluble (Weight Percent)**	**Water-Insoluble (Weight Percent)**
Al	0.541	5.13×10^{-2}
Bi	n/a	n/a
Cd	n/a	2.30×10^{-2}
Cl	9.55×10^{-2}	n/a
CO_3	0.61 (rerun 5.0)	n/a
Cr	0.430	n/a
Fe	n/a	1.29×10^{-2}
F	2.04×10^{-2}	n/a
Hg	4.49×10^{-3}	n/a
La	n/a	n/a
Mn	n/a	n/a
Na	22.2	n/a
Ni	n/a	n/a
NO_3	44.0 (rerun 43.2)	$<7 \times 10^{-2}$
OH	0.651	n/a
Pb	n/a	n/a
PO_4	0.622	1.94×10^{-3}
Si	2.57×10^{-2}	n/a
SO_4	1.63	<0.1
Zr	n/a	n/a
NO_2	1.36	n/a
Ca	n/a	7.19×10^{-3}
TOC	n/a	n/a

Table B4-1. Tank 241-S-111 Data Reported September 18, 1980.[1,2] (2 sheets)

Radiological Analysis		
Component	**Water-Soluble (μCi/g)**	**Water-Insoluble (μCi/g)**
^{241}Am (g/g)	2.51×10^{-11}	n/a
^{127}Cs	69.4	12.3
Pu (g/g)	1.57×10^{-9}	7.05×10^{-8}
$^{89+90}$Sr	1.37	16.0
U (g/g)	n/a	4.02×10^{-5}
^{60}Co	n/a	5.65×10^{-2}
^{106}Ru	n/a	0.965
^{154}Eu	n/a	0.181
^{155}Eu	n/a	0.495
Physical Analysis		
Component	**Value**	**Units**
Water	10.7	Weight percent
Bulk density	1.27	g/cm^3
Particle density	1.34	g/cm^3

Note:

[1]Bratzel (1980)

[2]Quality assurance and quality control parameters for performing this work are not well documented. The data should be used with caution.

Table B4-2a. 1978 Core Sample Data, Sample 1001-C.[1,2] (2 sheets)

Physical Data		
Component	Lab Value	Lab Unit
Bulk density	1.27	g/cm^3
Particle density	1.34	g/cm^3
Water content	10.7	Weight percent
Calculated heat content	5.74 x 10^{-4}	Watts/L
Sample size (core length)	43.2	cm
Hardness	26.0	kg/cm^2
Vapor pressure	8.9	mm Hg at 24.6°C
Drainable liquid	12.6	% at 28 psi
Material balance	99.8	%
DTA	No exotherms; endotherms at 103 °C and 285 °C (217 °F and 545 °F)	
Chemical Analysis		
Component	Water Soluble (%)	Acid (KOH Fusion) (%)
Al	0.6	0.06
Cl	0.1	n/a
Bi	n/a	n/a
Cd	<0.0002	0.003
Fe	n/a	0.02
F	0.02	n/a
CO_3	5.0	n/a
OH	1.0	n/a
Hg	0.004	n/a
K	n/a	n/a
Mn	n/a	n/a
Na	26.2	n/a
NO_2	0.9	n/a
NO_3	51.4	<0.3
PO_4	0.3	0.2
SO_4	1.5	<0.5
CrO_4	0.5	n/a
SiO_2	0.03	1.3
TOC (g/L)	1.29	n/a

Table B4-2a. 1978 Core Sample Data, Sample 1001-C.[1,2] (2 sheets)

Radiological Analysis		
Component	Water Soluble (μCi/g)	Acid (KOH Fusion) (μCi/g)
U (g/g)	n/a	2.47×10^{-5}
^{239}Pu (g/g)	3.60×10^{-10}	6.42×10^{-8}
^{241}Am (g/g)	1.02×10^{-10}	n/a
$^{89+90}$Sr	1.03	14.3
^{134}Cs	0.1	n/a
^{137}Cs	72.1	0.3
^{106}Ru	n/a	0.608
^{60}Co	n/a	0.056
^{125}Sb	n/a	0.007
^{154}Eu	n/a	0.150
^{155}Eu	n/a	0.307

Notes:

DTA = differential thermal analysis

[1]Horton (1978)

[2]Quality assurance and quality control parameters for performing this work are not well documented. The data should be used with caution.

Table B4-2b. 1978 Core Sample Data, Samples 1003-C and 1004-C.[1,2] (2 sheets)

Physical Data		
Component	Lab Value	Lab Unit
Bulk density	1.86	g/cm^3
Particle density	2.09	g/cm^3
Water content	17.4	Weight percent
Calculated heat content	1.84×10^{-3}	Watts/L
Sample size (core length)	50.8	cm
Hardness	n/a	kg/cm^2
Vapor pressure	8	mm Hg at 25.6 °C
Drainable liquid	n/a	% at
Material balance	108.4	%
DTA	No exotherms; endotherms at 110 °C and 285 °C (230 °F and 545 °F)	
Chemical Analysis		
Component	Water Soluble (%)	Acid (KOH Fusion) (%)
Al	1.3	0.09
Cl	0.005	n/a
Bi	0.001	n/a
Cd	<0.0003	n/a
Fe	0.0006	0.03
F	0.03	n/a
CO_3	5.0	n/a
OH	1.8	n/a
Hg	0.03	n/a
K	0.06	n/a
Mn	0.009	n/a
Na	23.0	n/a
NO_2	3.0	n/a
NO_3	53.0	0.3
PO_4	1.3	0.2
SO_4	2.7	<0.4
CrO_4	0.8	n/a
SiO_2	0.06	1.3
TOC (*M*)	2.38	n/a

Table B4-2b. 1978 Core Sample Data, Samples 1003-C and 1004-C.[1,2] (2 sheets)

Radiological Analysis		
Component	Water Soluble (μCi/g)	Acid (KOH Fusion) (μCi/g)
U (g/g)	n/a	2.83×10^{-5}
^{239}Pu (g/g)	2.12×10^{-8}	9.82×10^{-8}
^{241}Am (g/g)	4.03×10^{-11}	2.03×10^{-9}
$^{89+90}$Sr	1.2	15.20
^{134}Cs	n/a	n/a
^{137}Cs	180.0	2.40
^{106}Ru	n/a	n/a
^{60}Co	n/a	n/a
^{125}Sb	n/a	n/a
^{154}Eu	n/a	n/a
^{155}Eu	n/a	0.26

Note:

[1]Horton (1978)

[2]Quality assurance and quality control parameters for performing this work are not well documented. The data should be used with caution.

Table B4-2c. 1978 Core Sample Data, Sample 1009-C.[1,2] (2 sheets)

Physical Data		
Component	Lab Value	Lab Unit
Bulk density	1.44	g/cm^3
Particle density	1.56	g/cm^3
Water content	18.1	Weight percent
Calculated heat content	9.49×10^{-4}	Watts/L
Sample size (core length)	43.18	cm
Hardness	n/a	kg/cm^2
Vapor pressure	8.3	mm Hg at 26.3 °C
Drainable liquid	n/a	% at
Material balance	110.0	%
DTA	No exotherms; endotherms at 105 °C and 280 °C (221 °F and 536 °F)	
Chemical Analysis		
Component	Water Soluble (%)	Acid (KOH Fusion) (%)
Al	1.0	1.6
Cl	0.005	n/a
Bi	<0.04	n/a
Cd	0.0005	n/a
Fe	0.001	0.06
F	n/a	n/a
CO_3	12.0	n/a
OH	0.6	n/a
Hg	0.03	n/a
K	0.05	n/a
Mn	<0.001	n/a
Na	28.4	n/a
NO_2	2.1	n/a
NO_3	40.6	0.08
PO_4	1.2	0.02
SO_4	3.0	0.04
CrO_4	0.6	n/a
SiO_2	0.01	0.2
TOC (*M*)	2.80	n/a

Table B4-2c. 1978 Core Sample Data, Sample 1009-C.[1,2] (2 sheets)

Radiological Analysis		
Component	Water Soluble (μCi/g)	Acid (KOH Fusion) (μCi/g)
U (g/g)	n/a	3.51×10^{-6}
^{239}Pu (g/g)	4.25×10^{-9}	1.68×10^{-7}
^{241}Am (g/g)	4.23×10^{-11}	8.10×10^{-10}
$^{89+90}$Sr	1.71	17.3
^{134}Cs	n/a	n/a
^{137}Cs	109.9	0.60
^{106}Ru	1.16	n/a
^{60}Co	n/a	n/a
^{125}Sb	n/a	n/a
^{154}Eu	n/a	n/a
^{155}Eu	n/a	n/a

Note:

[1]Horton (1978)

[2]Quality assurance and quality control parameters for performing this work are not well documented. The data should be used with caution.

Table B4-2d. 1978 Core Sample Data, Sample 1009-C Supernatant.[1,2]

Physical Data		
Component	Lab Value	Lab Unit
Density	1.46	g/cm^3
Water content	44.6	Weight percent
Chemical Analysis		
Component	Molarity	Percentage
$NaAlO_2$	1.88	10.6
Ca	3.70×10^{-4}	0.001
Cd	1.62×10^{-4}	0.001
Hg	1.53×10^{-3}	0.02
K	4.21×10^{-2}	0.1
Mn	1.13×10^{-4}	0.0004
Fe	$<6.0 \times 10^{-4}$	<0.004
Na_2CO_3	0.21	1.5
NaOH	3.77	10.33
Na	9.60	15.11
$NaNO_2$	1.74	8.2
$NaNO_3$	0.75	4.4
Na_3PO_4	3.46×10^{-2}	0.4
Na_2SO_4	0.011	0.1
SiO_2	4.58×10^{-3}	0.02
Pb	3.44×10^{-4}	0.005
TOC (g/L)	6.2	n/a
Radiological Analysis		
Component	Lab Value	Lab Unit
Pu	8.95×10^{-6}	g/L
$^{89+90}Sr$	2.51×10^{3}	$\mu Ci/L$
^{137}Cs	4.68×10^{5}	$\mu Ci/L$

Note:

[1]Horton (1978)

[2]Quality assurance and quality control parameters for performing this work are not well documented. The data should be used with caution.

Table B4-2e. 1978 Core Sample Data, Analysis of Supernatant.[1,2]

Tank Supernatant Sample		
Physical Data		
Component	Lab Value	Lab Unit
Density	1.50	g/cm^3
Water content	46.0	Weight percent
Chemical Analysis		
Component	Molarity	Percentage
$NaAlO_2$	1.5	8.0
Ca	1.94×10^{-4}	0.0004
Cd	1.54×10^{-4}	0.001
Hg	1.41×10^{-3}	0.02
K	6.38×10^{-2}	0.2
Mn	9.28×10^{-5}	0.0003
Fe	1.85×10^{-3}	0.02
Na_2CO_3	8.20×10^{-2}	0.4
NaOH	3.68	9.8
Na	11.0	16.9
$NaNO_2$	1.82	8.3
$NaNO_3$	1.95	11.0
Na_3PO_4	8.74×10^{-2}	1.0
Na_2SO_4	3.18×10^{-2}	0.3
SiO_2	8.02×10^{-3}	0.04
TOC (g/L)	6.0	n/a
Radiological Analysis		
Component	Lab Value	Lab Unit
^{239}Pu	1.08×10^{-5}	g/L
$^{89+90}Sr$	2.04×10^{4}	$\mu Ci/L$
^{134}Cs	9.82×10^{2}	$\mu Ci/L$
^{137}Cs	6.82×10^{5}	$\mu Ci/L$

Note:

[1]Horton (1978)

[2]Quality assurance and quality control parameters for performing this work are not well documented. The data should be used with caution.

Table B4-3. Tank 241-S-111 Data Sampled December 27, 1976.[1,2]

Component	Lab Value	Lab Unit
Bulk density	1.41	g/cm^3
Particle density	1.50	g/cm^3
Water content	37.6	Weight percent
Al	2.6	Weight percent
CO_3	8.5	Weight percent
OH	0.4	Weight percent
Fe	0.1	Weight percent
NO_2	2.3	Weight percent
NO_3	34.0	Weight percent
Cr	0.5	Weight percent
Si	0.02	Weight percent
Na	21.0	Weight percent
PO_4	0.08	Weight percent
SO_4	0.3	Weight percent
Pu	1.10×10^{-7}	µCi/g
$^{89+90}Sr$	13.0	µCi/g
^{137}Cs	129.0	µCi/g

Note:

[1]Horton (1977)

[2]Quality assurance and quality control parameters for performing this work are not well documented. The data should be used with caution.

Table B4-4. Tank 241-S-111 Sample Data, December 16, 1974.[1,2]

Waste Tank 241-S-111, Sample T-8141		
Visual	Yellowish-green, 100% solids	
Radiation (over the top)	500 mRad/hr	
pH	>13.4	
Specific Gravity	1.7953	
Percent Water	34.29	
Al	1.34	*M*
F	5.10×10^{-3}	*M*
OH	5.16	*M*
Na	23.84	*M*
NO_2	2.761	*M*
NO_3	4.91	*M*
PO_4	4.52×10^{-2}	*M*
CO_3	0.293	*M*
Pu	3.44×10^{-5}	g/gal
^{134}Cs	1.13×10^{4}	μCi/gal
^{137}Cs	2.93×10^{6}	μCi/gal
^{60}Co	7.12×10^{2}	μCi/gal
$^{89+90}Sr$	2.33×10^{6}	μCi/gal
Cooling Curve Analysis		
Temperature (°C)	Time (minutes)	Percent Solids
40	45	10
35	45	10
30	45	15
25	45	18
20	60	20
15	45	20
10	45	25
5	120	30

Note:

[1]Wheeler 1974

[2]Quality assurance and quality control parameters for performing this work are not well documented. The data should be used with caution.

Table B4-5. Tank 241-S-111 Analytical Data Reported August 23, 1974.[1,2]

Component	Salt	Mother Liquor (Supernatant)	Units
Density	1.70 (bulk)	1.414	g/cm^3
Water	18.4	54.4	Weight percent
$NaAlO_2$	2.3	7.8	Weight percent
$NaNO_2$	2.7	8.1	Weight percent
$NaNO_3$	69.9	17.4	Weight percent
NaOH	6.6	10.7	Weight percent
Na_2CO_3	10.8	Not reported	Weight percent
Na_3PO_4	1.2	Not reported	Weight percent
^{137}Cs	96 μCi/g	4.47 x 10^5 μCi/L	As noted
$^{89/90}Sr$	7.54		μCi/g

Note:

[1]Horton and Buckingham (1974)

[2]Quality assurance and quality control parameters for performing this work are not well documented. The data should be used with caution.

Table B4-6. Tank 241-S-111 Data Reported May 29, 1974.[1,2]

Waste Tank 241-S-111		
Component	**Lab Value**	**Lab Units**
Damp Density	1.348	g/cm^3
Dry Density	1.21	g/cm^3
Heat Generation	12	μwatt/g
Water Content	9.46	Weight percent
$NaAlO_2$	0.22	Weight percent
NaOH	1.22	Weight percent
$NaNO_2$	0.09	Weight percent
$NaNO_3$	3.38	Weight percent
Na_2CO_3	1.01	Weight percent
Na_2SO_4	0.02	Weight percent
Na_2PO_4	0.03	Weight percent
Fe_2O_3	0.14	Weight percent
Al_2O_3	59.76	Weight percent
SiO_2	0.48	Weight percent
^{239}Pu	<0.2	μg/g
^{137}Cs	7.29	μCi/g
$^{89+90}Sr$	2.87	μCi/g

Note:

[1]Buckingham (1974)

[2]Quality assurance and quality control parameters for performing this work are not well documented. The data should be used with caution.

Table B4-7. Tank 241-S-111 Data Reported September 21, 1971.[1,2]

Waste Tank 241-S-111		
Component	**Lab Value**	**Lab Unit**
Specific gravity	1.219	n/a
Viscosity at 50 °C (122 °F)	0.96	Not reported
Al	0.49	*M*
Na	8.40	*M*
OH	1.92	*M*
CO_3	0.025	*M*
NO_2	0.30	*M*
NO_3	3.40	*M*
OH[(2)]	1.92	*M*
^{137}Cs	51.6	μCi/mL

Notes:

[1]Puryear (1971a and 1971b)

[2]Quality assurance and quality control parameters for performing this work are not well documented. The data should be used with caution.

B5.0 APPENDIX B REFERENCES

Babad, H., and J. S. Buckingham, 1974, *Analyses of Solidified Salt Wastes and Associated Mother Liquors*, (internal letter [number and addressee unknown], September 5), Atlantic Richfield Hanford Company, Richland, Washington.

Bratzel, D. R., 1980, *Evaluation of Waste Storage Tank Physical and Chemical Characterization Data*, (internal letter 65453-80-265 to F. M. Jungfleisch, September 18), Rockwell Hanford Operations, Richland, Washington.

Buckingham, J. S., 1974, *Analysis of Sludge Sample From Tank 111-S*, (internal letter [number unknown] to W. R. Christensen, May 29), Atlantic Richfield Hanford Company, Richland, Washington.

Burnum, S. T., 1995, *Qualification of Reported WHC Vapor Program Data*, (letter 95-CHD-065 to President, Westinghouse Hanford Company, August 18), U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Cashdollar, K. L., M. Hertzberg, I. A. Zlochower, C. E. Lucci, G. M. Green, and R. A. Thomas, 1992, *Laboratory Flammability Studies of Mixtures of Hydrogen, Nitrous Oxide, and Air*, WHC-SD-WM-ES-219, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Conner, J. M., 1996, *Tank 241-S-111 Push Mode Core Sampling and Analysis Plan*, WHC-SD-WM-TSAP-085, Rev. 0A, Westinghouse Hanford Company, Richland, Washington.

De Lorenzo, D. S., J. H. Rutherford, D. J. Smith, D. B. Hiller, K. W. Johnson, and B. C. Simpson, 1994, *Tank Characterization Reference Guide*, WHC-SD-WM-TI-648, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Dukelow, G. T., J. W. Hunt, H. Babad, and J. E Meacham, 1995, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

Ecology, EPA, and DOE, 1996, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and the U.S. Department of Energy, Olympia, Washington.

EPA, 1988, *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air*, PB90-127374, U.S. Environmental Protection Agency, Washington, D.C.

Fowler, K. D, 1995, *Data Quality Objectives for the Tank Farms Waste Compatibility Program*, WHC-SD-WM-DQO-001, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Hanlon, B. M., 1996, *Waste Tank Summary Report for the Month Ending October 31, 1996*, WHC-EP-0182-103, Lockheed Martin Hanford Corporation, Richland, Washington.

Harville, D. A., 1977, "Maximum Likelihood Approaches to Variance Component Estimation and to Related Problems," *Journal of the American Statistical Association*, vol. 72, pp. 320-340.

Hendrickson, R. W., 1995, *Tank Vapor Characterization Oak Ridge National Laboratories Quality Assurance Assessment*, TWRSQA-95-0012, Westinghouse Hanford Company, Richland, Washington.

Homi, C. S., 1995, *Vapor Sampling and Analysis Plan*, WHC-SD-WM-TP-335, Rev. 0G, Westinghouse Hanford Company, Richland, Washington.

Horton, J. E. and J. S. Buckingham, 1974, *Analyses of Salt Sample From 242-S Evaporator Slurry Receiving Tanks 105-S, 106-S and 111-S*, (internal letter [number unknown] to N. L. Harms, August 23), Atlantic Richfield Hanford Company, Richland, Washington.

Horton, J. E., 1977, *Analysis of Tank 111-S Salts*, (internal letter [number unknown] to W. R. Christensen, February 28), Atlantic Richfield Hanford Company, Richland, Washington.

Horton, J. E., 1978, *Chemical and Physical Analysis of Core Segments from Tank 111-S*, (internal letter 60120-78-087 to G. K. Allen, August 25), Rockwell Hanford Operations, Richland, Washington.

Huckaby, J. L., and D. R. Bratzel, 1995, *Tank 241-S-111 Headspace Gas and Vapor Characterization Results for Samples Collected in March 1995*, WHC-SD-WM-ER-507, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Jenkins, R. A, A. B. Dindal, C. Y. Ma, M. A. Palausky, J. T. Skeen, and C. K. Bayne, 1995, *Analysis of Tank 241-S-111 Headspace Components*, ORNL-CASD-FR-241S111.95, Rev. 0, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Jensen, L., R. D. Cromar, S. R. Wilmarth, and P. G. Heasler, 1995, *Number of Core Samples: Mean Concentrations and Confidence Intervals*, WHC-SD-WM-TI-674, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Klinger, G. S., T. W. Clauss, M. W. Ligotke, K. H. Pool, B. D. McVeety, K. B. Olsen, O. P. Bredt, J. S. Fruchter, and S. C. Goheen, 1995, *Vapor Space Characterization of Waste Tank 241-S-111: Results from Samples Collected on 3/21/95*, PNL-10733, Pacific Northwest Laboratory, Richland, Washington.

Mahlum, D. D., J. Y. Young, and R. E. Weller, 1994, *Toxicologic Evaluation of Analytes from Tank 231-C-103*, PNL-10189, Pacific Northwest Laboratory, Richland, Washington.

Osborne, J. W., J. L. Huckaby, E. R. Hewitt, C. M. Anderson, D. D. Mahlum, B. A. Pulsipher, and J. Y. Young, 1995, *Data Quality Objectives for Generic In-Tank Health and Safety Vapor Issue Resolution*, WHC-SD-WM-DQO-002, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Public Law 101-510, 1990, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation," Section 3137 of *National Defense Authorization Act for Fiscal Year 1991*.

Puryear, D. A., 1971a, *Analysis of Tanks 110-S, 111-S, and 112-S*, (internal letter [number unknown] to J. O. Skolrud, July 20), Atlantic Richfield Hanford Company, Richland, Washington.

Puryear, D. A., 1971b, *Characterization of S, U, and SX Waste Tanks*, (internal letter [number unknown] to J. O. Skolrud, September 21), Atlantic Richfield Hanford Company, Richland, Washington.

Simpson, B. C., and D. J. McCain, 1995, *Historical Model Evaluation Data Requirements*, WHC-SD-WM-DQO-118, Rev. 0A, Westinghouse Hanford Company, Richland, Washington.

Snedecor, G. W., and W. G. Cochran, 1980, *Statistical Methods*, 7th Edition, Iowa State University Press, Ames, Iowa.

Statistical Sciences, Inc., 1993, *S-PLUS™ Reference Manual, Version 3.2*, Seattle: StatSci, a division of MathSoft, Inc..

Steen, F. H., 1996, *Tank 241-S-111, Cores 149 and 150, Analytical Results for the Final Report*, WHC-SD-WM-DP-195, Rev. 1, Rust Federal Services of Hanford, Inc., Richland, Washington.

Turner, D. A., H. Babad, L. L. Buckley, and J. E. Meacham, 1995, *Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue*, WHC-SD-WM-DQO-006, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

Wheeler, R. E., 1974, *Analysis of Tank Farm Samples*, (internal letter [number unknown] to R. L. Walser, December 16), Atlantic Richfield Hanford Company, Richland, Washington.

Wilkins, N. E., R. E. Bauer, and D. M. Ogden, 1996, *Results of Vapor Space Monitoring of Flammable Gas Watch List Tanks*, HNF-SD-WM-TI-797, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

This page intentionally left blank.

APPENDIX C

STATISTICAL ANALYSIS FOR ISSUE RESOLUTION

C1.0 STATISTICS FOR SAFETY SCREENING DATA QUALITY OBJECTIVE

The safety screening DQO (Dukelow et al. 1995) defines acceptable decision confidence limits in terms of one-sided 95 percent confidence intervals. This appendix reports the results of one-sided confidence limits supporting the safety screening DQO for tank 241-S-111. The data are from the final laboratory data package for the 1996 core sampling event for tank 241-S-111 (Steen 1996).

Confidence intervals were computed for each sample number from tank 241-S-111 analytical data. Tables C1-1 and C1-2 provide sample numbers and confidence intervals for alpha and DSC, respectively.

The upper limit (UL) of a one-sided 95 percent confidence interval on the mean is

$$\hat{\mu} + t_{(df,0.05)} * \hat{\sigma}_{\hat{\mu}}.$$

In this equation, $\hat{\mu}$ is the arithmetic mean of the data, $\hat{\sigma}_{\hat{\mu}}$ is the estimate of the standard deviation of the mean, and $t_{(df,0.05)}$ is the quantile from Student's t distribution with degrees of freedom (df) for a one-sided 95 percent confidence interval.

For tank 241-S-111 data (per sample number), df equals the number of observations minus one.

Table C1-1 lists the UL of the 95 percent confidence interval for each sample number based on alpha data. Each confidence interval can be used to make the following statement. If the UL is less than 41 μCi/g (61.5 μCi/mL for drainable liquid), reject the null hypothesis that the alpha is greater than or equal to 41 μCi/g (61.5 μCi/mL for drainable liquid) at the 0.05 level of significance. All calculated confidence intervals are below the UL for total alpha.

Table C1-2 lists the UL of the 95 percent confidence interval for each sample number based on DSC data. Each confidence interval can be used to make the following statement. If the UL is less than 480 J/g, reject the null hypothesis that DSC is greater than or equal to 480 J/g at the 0.05 level of significance. All calculated confidence intervals are below the UL for energetics by DSC.

Table C1-1. 95 Percent Confidence Interval Upper Limits for Alpha for Tank 241-S-111 (Units are μCi/g or μCi/mL).

Sample Number	Sample Description	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	UL
S96T003360[1,2]	Core 149, segment 1, drainable liquid	6.89E-03	1.69E-03	1.76E-02
S96T003361[1,2]	Core 149, segment 2, drainable liquid	6.91E-03	0.00E+00	6.91E-03
S96T003362[1,2]	Core 149, segment 3, drainable liquid	1.02E-02	1.66E-03	2.07E-02
S96T003398	Core 149, segment 3, whole segment	2.96E-02	1.80E-03	4.10E-02
S96T003407	Core 149, segment 4, lower half	4.81E-02	7.50E-04	5.28E-02
S96T003408	Core 149, segment 5, lower half	2.34E-02	2.85E-03	4.13E-02
S96T003409	Core 149, segment 6, lower half	2.70E-02	5.00E-04	3.02E-02
S96T003410	Core 149, segment 7, lower half	2.07E-02	3.50E-04	2.29E-02
S96T003411	Core 149, segment 8, lower half	3.26E-02	5.35E-03	6.63E-02
S96T003412	Core 149, segment 9, lower half	7.05E-02	2.16E-02	2.07E-01
S96T003619[1,2]	Core 149, segment 10, upper half	3.45E-03	2.40E-04	4.97E-03
S96T003413	Core 149, segment 11, upper half	1.85E-03	8.00E-05	2.36E-03

Notes:

[1]Sample result is less than the detection limit.

[2]Duplicate result is less than the detection limit.

Table C1-2. 95 Percent Confidence Interval Upper Limits for DSC for Tank 241-S-111 (Units are J/g-Dry). (2 sheets)

Sample Number	Sample Description	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	UL
S96T003360	Core 149, segment 1, drainable liquid	0.00E+00	0.00E+00	0.00E+00
S96T003361	Core 149, segment 2, drainable liquid	0.00E+00	0.00E+00	0.00E+00
S96T003362	Core 149, segment 3, drainable liquid	0.00E+00	0.00E+00	0.00E+00

Table C1-2. 95 Percent Confidence Interval Upper Limits for DSC for Tank 241-S-111 (Units are J/g-Dry). (2 sheets)

Sample Number	Sample Description	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	UL
S96T003346	Core 149, segment 3, whole segment	1.42E+02	1.05E+01	2.08E+02
S96T003347	Core 149, segment 4, upper half	7.35E+01	2.15E+00	8.70E+01
S96T003348	Core 149, segment 4, lower half	6.95E+01	2.80E+00	8.72E+01
S96T003349	Core 149, segment 5, upper half	0.00E+00	0.00E+00	0.00E+00
S96T003350	Core 149, segment 5, lower half	0.00E+00	0.00E+00	0.00E+00
S96T003351	Core 149, segment 6, upper half	5.15E+01	4.60E+00	8.05E+01
S96T003352	Core 149, segment 6, lower half	0.00E+00	0.00E+00	0.00E+00
S96T003353	Core 149, segment 7, upper half	7.25E+01	1.95E+00	8.48E+01
S96T003354	Core 149, segment 7, lower half	0.00E+00	0.00E+00	0.00E+00
S96T003355	Core 149, segment 8, upper half	0.00E+00	0.00E+00	0.00E+00
S96T003356	Core 149, segment 8, lower half	0.00E+00	0.00E+00	0.00E+00
S96T003357	Core 149, segment 9, upper half	2.31E+01	5.95E+00	6.06E+01
S96T003358	Core 149, segment 9, lower half	0.00E+00	0.00E+00	0.00E+00
S96T003617	Core 149, segment 10, upper half	0.00E+00	0.00E+00	0.00E+00
S96T003359	Core 149, segment 11, upper half	0.00E+00	0.00E+00	0.00E+00

C2.0 STATISTICS FOR THE ORGANIC DATA QUALITY OBJECTIVE

The organic DQO (Turner et al. 1995) defines acceptable decision confidence limits in terms of one-sided 95 percent confidence intervals. This appendix reports one-sided confidence limits supporting the organic DQO for tank 241-S-111. All data are taken from the final laboratory data package for the 1996 core sampling event for tank 241-S-111 (Steen 1996).

Confidence intervals were computed for each sample number from tank 241-S-111 analytical data. Tables C1-3 and C1-4 provide the sample numbers and confidence intervals for percent water and TOC, respectively.

For percent water, the lower limit (LL) of a one-sided 95 percent confidence interval for the mean is

$$\hat{\mu} - t_{(df,0.05)} * \hat{\sigma}_{\hat{\mu}}$$

and for TOC, the UL of a one-sided 95 percent confidence interval for the mean is

$$\hat{\mu} + t_{(df,0.05)} * \hat{\sigma}_{\hat{\mu}}.$$

For these equations, $\hat{\mu}$ is the arithmetic mean of the data, $\hat{\sigma}_{\hat{\mu}}$ is the estimate of the standard deviation of the mean, and $t_{(df,0.05)}$ is the quantile from Student's t distribution with degrees of freedom (df) for a one-sided 95 percent confidence interval.

For the tank 241-S-111 data (per sample number), df equals the number of observations minus one.

Table C1-3 lists the LL of the 95 percent confidence interval for each sample number based on percent water data. Each confidence interval can be used to make the following statement. If the LL is greater than 17 percent, reject the null hypothesis that the percent water is less than or equal to 17 percent at the 0.05 level of significance. The LL was less than 17 percent for 4 of the samples.

Table C1-4 lists the UL of the 95 percent confidence interval for each sample number based on TOC data. Each confidence interval can be used to make the following statement. If the UL is less than 30,000 μg/g, reject the null hypothesis that TOC is greater than or equal to 30,000 μg/g at the 0.05 level of significance. The units for TOC drainable liquid samples were converted from μg/mL to μg/g using the specific gravity results for each sample number. All calculated ULs were below the action limit of 30,000 μg/g.

Table C1-3. 95 Percent Confidence Interval Lower Limits for Percent Water for Tank 241-S-111 (Units are in Percent). (2 sheets)

Sample Number	Sample Description	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	LL
S96T003360	Core 149, segment 1, drainable liquid	5.34E+01	4.50E-02	5.32E+01
S96T003361	Core 149, segment 2, drainable liquid	5.33E+01	7.00E-02	5.28E+01
S96T003362	Core 149, segment 3, drainable liquid	5.28E+01	1.00E-01	5.22E+01
S96T003346	Core 149, segment 3, whole segment	5.09E+01	3.25E-01	4.89E+01
S96T003347	Core 149, segment 4, upper half	4.30E+01	0.00E+00	4.30E+01
S96T003348	Core 149, segment 4, lower half	3.82E+01	2.98E+00	1.94E+01
S96T003349	Core 149, segment 5, upper half	2.81E+01	1.32E+00	1.97E+01

Table C1-3. 95 Percent Confidence Interval Lower Limits for Percent Water for Tank 241-S-111 (Units are in Percent). (2 sheets)

Sample Number	Sample Description	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	LL
S96T003350	Core 149, segment 5, lower half	3.65E+01	2.39E+00	2.14E+01
S96T003351	Core 149, segment 6, upper half	2.67E+01	0.00E+00	2.67E+01
S96T003352	Core 149, segment 6, lower half	2.94E+01	3.50E-02	2.92E+01
S96T003353	Core 149, segment 7, upper half	2.75E+01	4.30E-01	2.47E+01
S96T003354	Core 149, segment 7, lower half	2.17E+01	1.05E+00	1.51E+01
S96T003355	Core 149, segment 8, upper half	2.29E+01	1.60E-01	2.19E+01
S96T003356	Core 149, segment 8, lower half	2.51E+01	2.61E+00	8.58E+00
S96T003357	Core 149, segment 9, upper half	2.99E+01	2.10E-01	2.86E+01
S96T003358	Core 149, segment 9, lower half	3.60E+01	1.51E+00	2.65E+01
S96T003617	Core 149, segment 10, upper half	1.16E+01	2.00E-01	1.04E+01
S96T003359	Core 149, segment 11, upper half	1.06E+01	3.30E-01	8.50E+00

Table C1-4. 95 Percent Confidence Interval Upper Limits for TOC for Tank 241-S-111 (Units are in μg/g-Dry). (2 sheets)

Sample Number	Sample Description	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	UL
S96T003360	Core 149, segment 1, drainable liquid	2.17E+03	1.02E+02	2.82E+03
S96T003361	Core 149, segment 2, drainable liquid	2.24E+03	0.00E+00	2.24E+03
S96T003362	Core 149, segment 3, drainable liquid	2.22E+03	1.17E+02	2.95E+03
S96T003346	Core 149, segment 3, whole segment	7.08E+03	1.15E+03	1.04E+04
S96T003347	Core 149, segment 4, upper half	6.43E+03	1.01E+03	1.28E+04
S96T003348	Core 149, segment 4, lower half	6.06E+03	7.28E+01	6.52E+03
S96T003349	Core 149, segment 5, upper half	3.07E+03	3.62E+02	5.36E+03
S96T003350	Core 149, segment 5, lower half	3.55E+03	1.81E+02	4.69E+03
S96T003351	Core 149, segment 6, upper half	3.64E+03	2.73E+01	3.81E+03

Table C1-4. 95 Percent Confidence Interval Upper Limits for TOC for Tank 241-S-111 (Units are in μg/g-Dry). (2 sheets)

Sample Number	Sample Description	$\hat{\mu}$	$\hat{\sigma}_{\hat{\mu}}$	UL
S96T003352	Core 149, segment 6, lower half	3.39E+03	1.70E+02	4.46E+03
S96T003353	Core 149, segment 7, upper half	3.77E+03	2.83E+02	5.55E+03
S96T003354	Core 149, segment 7, lower half	2.21E+03	6.38E+00	2.25E+03
S96T003355	Core 149, segment 8, upper half	2.33E+03	2.14E+02	2.95E+03
S96T003356	Core 149, segment 8, lower half	2.60E+03	2.14E+02	3.95E+03
S96T003357	Core 149, segment 9, upper half	3.44E+03	5.71E+01	3.80E+03
S96T003358	Core 149, segment 9, lower half	2.29E+03	1.64E+02	3.33E+03
S96T003617	Core 149, segment 10, upper half	8.50E+02	1.47E+01	9.43E+02
S96T003359	Core 149, segment 11, upper half	5.98E+02	9.21E+01	8.67E+02

C3.0 APPENDIX C REFERENCES

Dukelow, G. T., J. W. Hunt, H. Babad, and J. E. Meacham, 1995, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

Steen, F. H., 1996, *Tank 241-S-111, Cores 149 and 150, Analytical Results for the Final Report*, WHC-SD-WM-DP-195, Rev. 1, Rust Federal Services of Hanford, Inc., Richland, Washington.

Turner, D. A., H. Babad, L. L. Buckley, and J. E. Meacham, 1995, *Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue*, WHC-SD-WM-DQO-006, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-S-111

This page intentionally left blank.

APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-S-111

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available chemical information for tank 241-S-111 was performed, and a best-basis inventory was established. This work follows the methodology established by the standard inventory task.

D1.0 CHEMICAL INFORMATION SOURCES

- Sample data in Appendix B, core 149 segments 1 through 11.
- Samples from other S and U farm tanks with similar SMMS1 saltcake waste types.
- Sample data from other S farm tanks with R1 and CWR1 (REDOX cladding waste) sludge waste type.
- The HDW Model document (Agnew et al. 1996) provides tank content estimates in terms of component concentrations and inventories.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

Tables D2-1 and D2-2 show HDW model inventories and sample data from tank 241-S-111. The waste volume used to generate the HDW inventory is 2,040 kL (538 kgal) total waste which is partitioned into 295 kL (78 kgal) sludge, 1,511 kL (399 kgal) saltcake, and 231 kL (61 kgal) unknown waste (Agnew et al. 1996). The HDW waste density was 1.59 g/mL.

The sampling-based inventory was generated using a solid waste volume of 1960 kL (517 kgal). The volume of liquid in the tank is less than 5 percent of the total volume, and the liquids will be pumped from the tank during stabilization activities. Therefore, only the solids were used to estimate the inventory. Waste volume estimates are described in Appendix A. The solids consist of 530 kL (139 kgal) of sludge and 1,430 kL (378 kgal) of saltcake. The derivation of the best-basis sampling inventory estimate is described in Section D4.2.

Table D2-1. Sample-Based and Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-S-111.

Analyte	Sampling Inventory Estimate[1] (kg)	HDW[2] Inventory Estimate (kg)	Analyte	Sampling Inventory Estimate[1] (kg)	HDW[2] Inventory Estimate (kg)
Al	254,000	131,000	NO_3	707,000	597,000
Bi	174	316	OH	n/r	353,000
Ca	497	4,820	oxalate	17,300	1.85
Cd	17	n/r	Pb	n/r	1,410
Cl	9,000	13,700	P as PO_4	25,300	12,300
Cr	15,100	18,100	Si	745	4,210
F	2,390	1,600	S as SO_4	52,000	38,200
Fe	2390	15,300	Sr	14	0.718
Hg	n/r	39.7	TIC as CO_3	30,500	43,100
K	2,330	3,880	TOC	6,600	15,700
La	n/r	3.41	U_{total}	639	8,810
Mn	151	366	Zn	848	n/r
Mo	93	n/r	Zr	15	94
Na[3]	581,000	524,000	H_2O (Wt%)	28.7	36
Ni	101	1,440	Density (kg/L)	1.78	1.59
NO_2	91,900	263,000			

Notes:

[1]Sampling inventory calculated as described in Section D4.2.
[2]Agnew et al. (1996)

Table D2-2. Sampling and HDW Predicted Inventory Estimates for Radioactive Components in Tank 241-S-111[1].

Analyte	Sampling Inventory Estimate (Ci)	HDW[2] Inventory Estimate (Ci)	Analyte	Sampling Inventory Estimate (Ci)	HDW[2] Inventory Estimate (Ci)
^{90}Sr	51,200	338,000	$^{239/240}Pu$	Not analyzed	264
^{137}Cs	418,000	539,000			

Notes:

[1]Decayed to January 1, 1994

[2]Agnew et al. (1996)

D3.0 COMPONENT INVENTORY EVALUATION

D3.1 WASTE HISTORY TANK 241-S-111

Tank 241-S-111 is the second tank in a three-tank cascade series that includes tanks 241-S-110 and 241-S-112. From 1952 until 1957, the tank waste cascaded from tank 241-S-110, which was receiving first cycle REDOX waste and REDOX cladding waste (CWR) during that time. Beginning in 1974, transfers of supernate were made to tank 241-S-102 began in 1974. Evaporator bottoms were returned, eventually filling the tank. A pump was installed and pumping of interstitial liquids was initiated in 1976. Between 1976 and 1978, a total of 935 kL (247 kgal) of liquid was pumped. The tank was primary stabilized in March 1978 and partially isolated in December 1982.

The tank is on the Hydrogen Watch List. It is passively ventilated and is categorized as sound with partial interim isolation completed. Appendix A contains a more detailed waste transfer history.

D3.2 EVALUATION OF TANK WASTE VOLUME

The tank 241-S-111 surface level is monitored with both an auto and manual ENRAF™ gauge. The surface level for the past year has remained steady with the readings ranging from 518.5 cm to 516.7 cm (204.15 to 203.43 in.). As of January 21, 1997, the tank surface-level height recorded from the Surveillance Analysis Computer System was 518 cm (203.8 in.) which corresponds to 2,040 kL (540 kgal) of total waste in tank 241-S-111.

D3.3 CONTRIBUTING WASTE TYPES

The HDW model (Agnew et al. 1996) predicts that the tank contains a total of 2,040 kL (538 kgal) of waste, consisting of 250 kL (66 kgal) of first cycle REDOX high-level waste (R1), 45 kL (12 kgal) of cladding waste from the REDOX process (CWR1), 231 kL (61 kgal) of an unknown waste, and 1,510 kL (399 kgal) of saltcake (SMMS1) predicted from the SMM.

The sort on radioactive waste type (SORWT) model (Hill et al. 1995) lists REDOX high-level waste, and evaporator bottoms (EB) as the primary and secondary waste types, respectively. Evaporator bottoms waste is the SORWT definition for saltcake that is equivalent to the SMM waste type.

D3.4 INVENTORY EVALUATION

The following evaluation provides an engineering assessment of tank 241-S-111 contents. For this evaluation, the following assumptions and observations are made:

- The tank volume of 2,040 kL (540 kgal) estimated in Appendix A is assumed to be correct.
- The supernatant contribution is not significant to the overall waste inventory (less than 5 percent by volume). In addition, liquids will be pumped from the tank. Therefore, the volume used to estimate the inventory is the solids volume of 1960 kL (517 kgal).
- Only SMMS1, REDOX, and CWR1 waste streams contributed to solids formation.

D3.5 BASIS FOR CALCULATIONS USED IN THIS ENGINEERING EVALUATION

Table D3-1 lists the approaches used for calculating and checking the supernatant, saltcake, and sludge inventories of tank 241-S-111.

Table D3-1. Engineering Evaluation Approaches Used On Tank 241-S-111.

Type of Waste	How Calculated	Check Method
Supernatant	Assumed no supernatant. (Although 87 kL [23 kgal] of supernatant is estimated, this liquid will be removed by salt well pumping.)	n/a
Saltcake Volume = 1,430 kL (378 kgal) Density = 1.68 g/mL	Used sampling based concentrations for tank 241-S-111.	SMMS1 average concentrations from other S and U Tank Farm tanks with sample data available.
Sludge Volume = 526 kL (139 kgal) Density = 1.67 g/mL	Used sampling based concentrations for tank 241-S-111.	Average sludge concentrations from other S Farm tanks with sample data available.

D3.5.1 Basis for Saltcake Calculations

The saltcake and sludge segment data for the tank 241-S-111 core sample were evaluated and compared to average concentrations of sample data from tanks with similar saltcake and sludge waste types. Based on extrusion observations and analytical data, the sample data for segments 4 through 8 were used to estimate the concentration of the saltcake layer. Data on the solids of segment 3 were excluded as less than 15 g were recovered. Data from Segment 9 were not used as this segment is transitional between the saltcake and sludge. The results for segments 4 through 8 were averaged to get the mean saltcake concentration for the tank, which was compared to analyses for other tanks using the check method described below.

The check method used is based on comparing data sets from S and U Tank Farm samples. Tanks 241-S-101, 241-S-102, 241-U-106, and 241-U-109 were used to produce the average saltcake analyte concentrations for SMMS1 saltcake. Agnew et al. (1996) indicates SMMS1 waste for all these tanks. To calculate the average SMMS1 concentration, the waste volumes and predicted location from the HDW model for the SMMS1 layer in each tank was determined. The TCR sample data was reviewed and using the segments located in the predicted location from the HDW model, an average concentration was calculated.

Table D3-2 shows the concentrations from each tank and the segments used in the calculation. The average component concentrations for the four tanks are also shown. For comparison, the SMMS1 saltcake composition predicted by the HDW model for tank 241-S-111 is shown.

Table D3-2. SMMS1 Saltcake Concentrations from Sampling Data and Modeling.[1] (2 sheets)

Analyte	S-101[2] Segments 2L-4U	S-102[2] Segments 7L-10U	U-106[2] Segments 2U-4L	U-109[2] Segments 5U-8L	Average of Tank Samples	S-111[2] Sample Segments 4-8	HDW Model SMM for S-111
Al	18,000	15,085	13,620	13,625	15,100	15,000	32,100
Ag	12	17	16	n/r	15	15	n/r
B	110	75	80	n/r	88	112	n/r
Bi	71	76	336	<DL[3]	161	60	113
Ca	273	237	336	<DL	282	148	881
Cl	4,500	4,099	2,926	3560	3,770	2,980	4,790
Cr	10,000	4,359	3,170	4,233	5,440	5,470	2,430
F	500	13,600	4,669	298	4,840	972	575
Fe	508	1,298	3,096	<DL	1,630	222	270
K	1,109	898	1,309	n/r	1,110	811	1,360
La	<DL	37	43	n/r	40	n/r	n/r
Mn	266	597	1,189	<DL	684	54	131
Na	150,000	189,500	170,500	218,000	182,000	216,000	180,000
Ni	114	49	304	<DL	155	37	249
NO_2	91,000	40,100	56,000	42,900	57,502	30,500	85,600
NO_3	110,000	99,200	147,200	297,000	163,000	281,000	213,000
Pb	91	137	348	n/r	192	46	110
PO_4	9,500	114,500	5,888	5,970	34,000	9,140	4,400

Table D3-2. SMMS1 Saltcake Concentrations from Sampling Data and Modeling.[1] (2 sheets)

Analyte	S-101[2] Segments 2L-4U	S-102[2] Segments 7L-10U	U-106[2] Segments 2U-4L	U-109[2] Segments 5U-8L	Average of Tank Samples	S-111[2] Sample Segments 4-8	HDW Model SMM for S-111
P	2,290	33,900	1,949	<DL	12,700	2,830	n/r
S	5,940	2,683	3,878	n/r	4,170	7,080	n/r
Si	5,269	517	176	<DL	1,990	157	1,470
SO_4	20,700	12,500	10,774	11,100	13,800	21,800	1,360
Sr	7	<DL	<DL	n/r	7	4.7	0.257
TOC	1,900	5,340	24,626	3,920	8,950	2,510	5,620
U	560	1,403	781	<DL	914	252	1,990
Zn	30	32	54	<DL	39	26	n/r
Zr	14	39	88	n/r	47	52	33.7
Oxalate	15,400	15,700	9,880	n/r	13,700	6,960	0.663

Notes:

DL = detectable limit

[1]All data in $\mu g/g$
[2]All analyte concentrations based on acid digest values for comparison.
[3]Less than the detectable limit

The average concentrations of F, PO_4, and P from the comparison tanks match better with tank 241-S-111 sample saltcake concentrations if the high values from tank 241-S-102 are removed. The average concentration would drop to 1,820 mg/g, 7,120 mg/g, and 2,120 mg/g for F, PO_4, and P, respectively.

D3.5.2 Basis for Sludge Calculations

Data from tank 241-S-111 core sample segments containing sludge waste were compared to average concentrations of sample data from tanks with similar sludge waste types. As estimated in Appendix A, tank 241-S-111 has 526 kL (139 kgal) of sludge. The analytical data for segments 10 and 11 or Core 149 were used to calculate the mean concentrations in the sludge. Segment 9 was not used as it is transitional between saltcake and sludge. This average sludge concentration for tank 241-S-111 is presented in Table D3-3.

An estimate of R1 and CWR1 sludge concentrations was derived from sampling data for other tanks in the S Tank Farm. Sample data from tanks 241-S-102, 241-S-104, and 241-S-107 were used to produce average analyte concentrations for R1 and CWR1 sludge waste. To calculate the average concentration, the volumes and predicted location of the sludge were taken from the HDW for the tank's R1 waste. The TCR sample data were reviewed. Only the segments located within the predicted sludge location from the HDW were used in deriving an average concentration. Table D3-3 shows the average concentration from each tank, the segments used, and the HDW model concentration for each analyte.

Table D3-3. R1/CWR1 Sludge Concentrations from Sampling Data and Modeling[1] (2 sheets)

Analyte	241-S-101[2] Segments 7U-8L	241-S-104[2] Total Conc.	241-S-107[2] Segments 7U-8L	Average Conc.	241-S-111[2] Segments 10-11	HDW Sludge Layer Conc. for 241-S-111
Al	127,000	117,000	56,400	100,100	249,000[3]	92,400
Ag	9.71	<DL	<DL	9.7	3.9	n/r
B	63.1	26.6	49	46.2	63	n/r
Bi	<DL	45.7	<DL	45.7	34	n/r
Ca	322	247	234	268	162	5,250
Cl	2,050	3,200	1,860	2,370	2,100	792
Cr	2,230	2,350	1,180	1,920	2,240[3]	2,520
F	n/r	145	150	148	61	n/r
Fe	1,960	1,720	1,160	1,610	47	32,300
K	539	300	457	432	433	190
Mn	2,750	1,150	83	1,330	209	n/r
Na	123,000	121,000	60,400	101,000	69,100[3]	48,400

Table D3-3. R1/CWR1 Sludge Concentrations from Sampling Data and Modeling[1] (2 sheets)

Analyte	241-S-101[2] Segments 7U-8L	241-S-104[2] Total Conc.	241-S-107[2] Segments 7U-8L	Average Conc.	241-S-111[2] Segments 10-11	HDW Sludge Layer Conc. for 241-S-111
Ni	90.7	56	206	118	13	1,650
NO_2	31,100	25,900	34,300	30,400	21,200	54,200
NO_3	102,000	119,000	57,600	92,900	35,300	4,770
Pb	37	29.6	33	33.2	34	2,450
PO_4	1,360	2,190	1,630	1,730	1,580	n/r
P	278	93.2	391	254	1,640	n/r
S	343	472	293	369	364	n/r
Si	1,360	1,330	1,060	1,250	420	240
SO_4	897	2,270	1,300	1,490	706	896
Sr	456	424	378	420	3.4	n/r
TOC	<DL	1,730	293	1,100	643	n/r
U	8,480	6,690	8,686	7,950	n/r	7,240
Zn	25.1	n/r	2.4	23.1	898[3]	n/r
Zr	36	33.6	131	66.7	3.4	n/r
Density	1.74	1.74	1.87	1.78	1.67	1.53

Notes:

Conc. = concentration

[1]All data in $\mu g/g$ except density (g/mL)
[2]All reported results for metals are based on acid digest results, except as noted.
[3]Fusion digestion results

Several analytes show large differences from tank to tank. Two tanks with Na and NO_3 concentrations have at least twice the concentration of tank 241-S-111. However the concentrations of these analytes in tank 241-S-107 compare favorably with tank 241-S-111. The aluminum value for tank 241-S-111 is much higher than the other tanks. In addition, the iron value for tank 241-S-111 sludge is about 35 times less than the other tanks. It is apparent that the sludge in tank 241-S-111 is almost exclusively CWR, while the waste in the other tanks may be closer to R1 waste (see Table 3-4).

D3.6 ESTIMATED COMPONENT INVENTORIES

Table D3-4 summarizes the estimated chemical inventories for tank 241-S-111: the sample-based inventory from tank 241-S-111, the predicted engineering assessment inventory, and the HDW model estimated inventory. The engineering assessment inventory is based on the average analytical concentrations from four tanks with SMMS1 saltcake (see Table D3-2) and three tanks with R1 and CWR1 sludge (see Table D3-3). The calculated concentrations for the saltcake and sludge components were converted to inventories based on the analytical density results and relative volumes predicted by Agnew et al. (1996) and were added together to provide the total tank inventory estimate.

Table D3-4. Estimated Chemical Inventory for Tank 241-S-111.

Component	Engineering Evaluation Inventory (kg)	Tank 241-S-111[1] Sample: Total Inventory (kg)	HDW Model Inventory (kg)
Al	88,600	254,000	131,000
Bi	205	174	316
Cr	14,400	15,100	18,100
F	11,80	2,390	1,600
Fe	4,850	575	15,300
K	2,940	2,330	3,880
Mn	2,370	151	366
Na	500,000	581,000	524,000
NO_3	450,000	707,000	597,000
PO_4	84,500	25,300	12,300
SO_4	34,700	52,000	38,200
TOC	22,500	6,600	15,700

Notes:

[1]From Table D4-1. (1996)

These inventory estimates for the tank were generated from independent sources. The HDW model provides tank composition estimates based on historical process and waste transfer records. The R1/CWR1 Sludge and SMMS1 Saltcake formulations were developed from analytical data on what was believed to be similar waste types. This tank also has analytical data from a 1996 sampling event. Thus, this engineering assessment provides an opportunity to compare data from the waste type formulation approach with the HDW model values and tank-specific analytical data.

Aluminum

Aluminum is expected to be in sludge and saltcake layers. The Al value for the four saltcake tanks shown in Table D3-2 is 15,100 μg/g. The sample based value is 15,000 μg/g agreeing with the values for the other tanks. The HDW SMM model value is 32,100 μg/g, a factor of two larger than either of the other two values. This factor has been seen in a number of S Tank Farm tanks. This may be caused by the lack of fusion data for the saltcake layers. Because of the lack of consistent fusion digest sample values, the analytical data is calculated on acid digest sample results. The sludge Al value is 249,000 μg/g (see Table D3-3) based on the fusion result. The analytical-based average concentration is 100,100 μg/g based on the average of acid digest sample results. The HDW model sludge concentration is 92,400 μg/g. The sample value is more then twice that of the other two values, which supports the conclusion that the sludge in tank 241-S-111 is mostly cladding waste.

Calcium

The HDW model predicts the Ca concentration would be approximately 6 times higher in the sludge than in the saltcake. However, both analytical and engineering assessment-based values indicate that the Ca concentrations are similar in saltcake and sludge. There appears to be considerably less Ca in the tank than predicted by the HDW model.

Chloride

The HDW model predicts the chloride concentration will be approximately 6 times higher in saltcake than in sludge. However, both the analytical data and the engineering assessment value predict that differences in chloride values between saltcake and sludge is less than a factor of two.

Chromium

In the sludge layer, there is agreement among the three concentration estimates for Cr. However, in the saltcake, the analytical value for Cr is approximately 2.7 times higher than the HDW model value. There is agreement between the engineering assessment value and the analytical value in the saltcake layer.

Iron

The analytical-based iron concentration in the sludge is far less than that predicted by the engineering assessment or the HDW model. The iron concentration predicted by the HDW model is approximately 690 times greater than the analytical-based value. The HDW model predicts R1 waste sludge in the tank, while the samples indicate that the sludge is cladding waste, which has considerably less iron.

Manganese

Potassium permanganate was used in the REDOX process until 1959; therefore manganese is expected to be in tanks containing waste from that process. Manganese is probably present as highly insoluble manganese dioxide in the alkaline waste materials and in the sludge. The R1/CWR1 sludge composition estimate developed in this engineering assessment for Mn was 1,330 μg/g. The SMMS1 saltcake composition estimate for Mn was 684 μg/g, much higher than would be expected based on solubility considerations. It should be noted that there are large ranges in the SMMS1 and R1 data sets for Mn. The HDW model predicts zero Mn in the sludge in tank 241-S-111 and 131 μg/g in the saltcake layer. Based on the analytical data, the Mn concentration in saltcake is 55 μg/g and in sludge 47 μg/g.

Phosphate

In the saltcake, a large difference exists between the engineering assessment concentration estimate and the HDW model and analytical-based estimates for phosphate. The engineering assessment value is biased high because of one extremely high phosphate value in data set used to develop the SMMS1 saltcake composition estimate (see Table D3-2). If the phosphate data from tank 241-S-102 are eliminated from the SMMS1 composition estimate, than the engineering assessment, analytical-based, and the HDW estimates would agree. The HDW model predicts zero phosphate in the sludge. The analytical-based and engineering assessment-based values are low (less than 2,000 μg/g phosphate).

D4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

D4.1 OVERVIEW

As part of this effort, evaluations were performed of the following chemical information for tank 241-S-111:

- The inventory estimate generated by the HDW model (Agnew et al. 1996)

- An engineering evaluation which produced a predicted SMMS1 inventory based on a methodology developed by evaluating tanks 241-S-102, 241-S-102, 241-U-107, and 241-U-109.
- An engineering evaluation of R1/CWR sludge based on sampling-based data from tanks 241-S-102, 241-S-104, and 241-S-107.
- Sample data from tank 241-S-111, reported in Appendix B.

Based on the evaluations, a best-basis inventory was developed for tank 241-S-111. Only one core was analyzed; therefore, the horizontal variability cannot be estimated. Variation between core samples (spatial variability) is often the largest source of variability in characterization samples (Jensen et al. 1995). Nevertheless and for the following reasons, the sample-based evaluation inventory was chosen as the best basis for those analytes for which sampling-based analytical values were available.

- The sampling-based inventory analytical concentrations of the other S and U tanks containing SMMS1 waste compared favorably with tank 241-S-111 sampling inventory.
- No methodology is available to fully predict SMMS1 saltcake from process flowsheet or historical records.
- Comparing sample-based sludge data from tank 241-S-111 to analytical data from other S Farm tanks provides strong evidence that the sludge in tank 241-S-111 is predominantly CWR rather than R1 waste.

D4.2 CALCULATION OF THE BEST-BASIS INVENTORY

The best-basis inventory is calculated using the mean saltcake and mean sludge concentrations for 241-S-111, presented in Tables D3-2 and D3-3. The volume of saltcake is assumed to be 1,430 kL (378 kgal) and the volume of sludge is assumed to be 526 (139 kgal), as estimated in Appendix A. The densities of saltcake and sludge are 1.68 and 1.67, respectively, derived from the sampling data for segments 4 through 8 for saltcake and 10 through 11 for sludge. The liquid data were not included in the inventory as the liquids will be pumped in the near future, and the volume of liquid is small relative to solids (less than 5 percent of total volume).

For certain analytes (total uranium and ^{90}Sr), data are only available from the core composite sample. The inventory for these analytes is calculated using the reported concentration, a solids volume of 1,957 kL (517 kgal), and a composite sample density of 1.78 g/mL. The inventory of ^{137}Cs is also calculated from the composite.

Certain other analytes were not measured analytically, or the results were below detection limits. For these, the engineering assessment or HDW model estimates were used. Tables D4-1 and D4-2 show the best-basis inventory for tank 241-S-111. The source of the data is listed for each analyte.

Table D4-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-S-111.

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]	Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]
Al	254,000[2]	S	Ni	101	S
Bi	174	S	NO_2	91,900	S
Ca	497	S	NO_3	707,000	S
Cl	9,000	S	OH	n/r	
Cr	15,100	S	Pb	141	E
F	2,390	S	P as PO_4	25,300	S
Fe	575	S	Si	745	S
Hg	39.7	M	S as SO_4	52,000	S
K	2,330	S	Sr	232	E
La	98	E	TOC	6,600	S
Mn	151	S	U_{TOTAL}	639	S
Na	581,000	S	Zr	15	S

Notes:

[1]S = sample-based, M = HDW model-based, E = engineering assessment-based

[2]Based on fusion digest sample results

Table D4-2. Best-Basis Inventory Estimates for Radioactive Components in Tank 241-S-111.[1]

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[2]	Analyte	Total Inventory (Ci)	Basis (S, M, or E)[2]
^{3}H	n/r		^{226}Ra	n/r	
^{14}C	n/r		^{227}Ac	n/r	
^{59}Ni	n/r		^{228}Ra	n/r	
^{60}Co	n/r		^{229}Th	n/r	
^{63}Ni	n/r		^{231}Pa	n/r	
^{79}Se	n/r		^{232}Th	n/r	
^{90}Sr	51,200	S	^{232}U	n/r	
^{90}Y	51,200	S	^{233}U	n/r	
^{93}Zr	n/r		^{234}U	n/r	
^{93m}Nb	n/r		^{235}U	n/r	
^{99}Tc	n/r		^{236}U	n/r	
^{106}Ru	n/r		^{237}Np	n/r	
^{113m}Cd	n/r		^{238}Pu	n/r	
^{125}Sb	n/r		^{238}U	n/r	
^{126}Sn	n/r		^{239}Pu	264	M
^{129}I	n/r		^{240}Pu	n/r	
^{134}Cs	n/r		^{241}Am	2,530	E
^{137}Cs	418,000	S	^{241}Pu	n/r	
^{137m}Ba	396,000	S	^{242}Cm	n/r	
^{151}Sm	n/r		^{242}Pu	n/r	
^{152}Eu	n/r		^{243}Am	n/r	
^{154}Eu	n/r		^{243}Cm	n/r	
^{155}Eu	n/r		^{244}Cm	n/r	

Notes:

[1]Radionuclides decayed to January 1, 1994

[2]S = sample-based, M = HDW model-based, E = engineering assessment-based

D5.0 APPENDIX D REFERENCES

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. Fitzpatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1996, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 3*, LA-UR-96-858, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

Hill, J. G., G. S. Anderson, and B. C. Simpson, 1995, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-Shell Tanks into Characteristic Groups*, PNL-9814, Rev. 2, Pacific Northwest Laboratory, Richland, Washington.

Hodgson, K. M, and M. D. LeClair, 1996, *Work Plan for Defining a Standard Inventory Estimate for Wastes Stored in Hanford Site Underground Tanks*, WHC-SD-WM-WP-311, Rev. 1, Lockheed Martin Hanford Corporation, Richland, Washington.

Jensen, L., R. D. Cromar, S. R. Wilmarth, and P. G. Heasler, 1995, *Number of Core Samples: Mean Concentrations and Confidence Intervals*, WHC-SD-WM-TI-674, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

APPENDIX E

BIBLIOGRAPHY FOR TANK 241-S-111

This page intentionally left blank.

APPENDIX E

BIBLIOGRAPHY FOR TANK 241-S-111

Appendix E is a bibliography of information that supports the characterization of tank 241-S-111. This bibliography represents an in-depth literature search of all known information sources that provide sampling, analysis, surveillance, and modeling information, as well as processing occurrences associated with tank 241-S-111 and its respective waste types.

The references in this bibliography are separated into the following categories and subgroups.

I. NON-ANALYTICAL DATA

- Ia. Models/Waste Type Inventories/Campaign Information
- Ib. Fill History/Waste Transfer Records
- Ic. Surveillance/Tank Configuration
- Id. Sample Planning/Tank Prioritization
- Ie. Data Quality Objectives/Customers of Characterization Data

II. ANALYTICAL DATA - SAMPLING OF TANK WASTE AND WASTE TYPES

- IIa. Sampling of Tank 241-S-111
- IIb. Sampling of 242-S Evaporator Streams
- IIc. Sampling of REDOX Waste

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

- IIIa. Inventories Using both Campaign and Analytical Information
- IIIb. Compendium of Existing Physical and Chemical Documented Data Sources

This bibliography is divided into appropriate sections of material with an annotation at the end of each reference describing the information source. When possible, a reference is provided for information sources. Most information listed below can be found in the Lockheed Martin Hanford Corporation Tank Characterization Resource Center.

I. NON-ANALYTICAL DATA

Ia. Models/Waste Type Inventories/Campaign Information

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

- Contains single-shell tank fill history and primary campaign/waste type information to 1981.

Hill, J. G., G. S. Anderson, and B. C. Simpson, 1995, *The Sort on Radioactive Waste Type Model: A Method to Sort Single-shell Tanks into Characteristic Groups*, PNL-9814, Rev. 2, Pacific Northwest Laboratory, Richland, Washington.

- Classifies tanks into waste types based on transfer history.

Jungfleisch, F. M., and B. C. Simpson, 1993, *Preliminary Estimation of the Waste Inventories in Hanford Tanks Through 1980*, WHC-SD-WM-TI-057, Rev. 0A, Westinghouse Hanford Company, Richland, Washington.

- A model based on process knowledge and radioactive decay estimations for different compositions of process waste streams assembled for total, solution, and solids compositions per tank. Assumptions about waste/waste types and solubility parameters/constraints are also given.

Boldt, A. L., 1966, *REDOX Chemical Flowsheet HW No. 9*, ISO-335, Atlantic Richfield Hanford Company, Richland, Washington.

Crawley, D. T., 1960, *REDOX Chemical Flowsheet, HW-No. 6*, 66203, General Electric Hanford Company, Richland, Washington.

Merrill, E. T., and R. L. Stevenson, 1955, *REDOX Chemical Flowsheet HW No. 5,* HW-38684, General Electric Hanford Company, Richland, Washington.

- Contains compositions of material balance for REDOX process and a separations plan showing process stream waste before transfer to 200 Area waste tanks.

Ib. Fill History/Waste Transfer Records

Agnew, S. F., R. A. Corbin, T. B. Duran, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1996, *Waste Status and Transaction Record Summary for the Southwest Quadrant of the Hanford 200 East Area*, WHC-SD-WM-TI-614, Rev. 2, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains spreadsheets showing available data on tank additions/transfers.

Anderson, J. D., 1990, *A History of the 200 Area Tank Farms*, WHC-MR-0132, Westinghouse Hanford Company, Richland, Washington.

- Contains single-shell tank fill history and primary campaign/waste type information up to 1981.

Ic. Surveillance/Tank Configuration

Alstad, A. T., 1993, *Riser Configuration Document for Single-Shell Waste Tanks*, WHC-SD-RE-TI-053, Rev. 9, Westinghouse Hanford Company, Richland, Washington.

- Shows tank riser locations in relation to tank aerial view and provides a description of the risers and their contents.

Lipnicki, J., 1996, *Waste Tank Risers Available for Sampling*, WHC-SD-WM-TI-710, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

- Assesses riser locations for each tank; not all tanks are included/completed. Also includes is an estimate of the risers available for sampling.

Tran, T. T., 1993, *Thermocouple Status Single-Shell & Double-Shell Waste Tanks*, WHC-SD-WM-TI-553, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Shows thermocouple status for waste tanks.

Id. Sample Planning/Tank Prioritization

Brown, T. M., S. J. Eberlein, J. W. Hunt and T. J. Kunthara, 1996, *Tank Waste Characterization Basis*, WHC-SD-WM-TA-164, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Summarizes the technical basis for characterizing tank waste and assigns a priority number to each tank.

Conner, J. M., and W. I. Winkelman, 1996, *Tank 241-S-111 Tank Characterization Plan*, WHC-SD-WM-TP-317, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

- Discusses DQOs applicable to tank 241-S-11 and how their requirements will be met.

Conner, J. M., 1996, *Tank 241-S-111 Push Mode Core Sampling and Analysis Plan*, WHC-SD-WM-TSAP-085, Rev. 0A, Westinghouse Hanford Company, Richland, Washington.

- Contains detailed sampling and analysis procedure information for tank 241-S-111 based on applicable DQOs.

Grimes, G. W., 1977, *Hanford Long-Term Defense High-Level Waste Management Program Waste Sampling and Characterization Plan*, RHO-CD-137, Rockwell Hanford Operations, Richland, Washington.

- Early characterization planning document.

Winkelman, W. D., J. W. Hunt, and L. J. Fergestrom, 1996, *FY 1997 Tank Waste Analysis Plan*, WHC-SD-WM-PLN-120, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Contains Tri-Party Agreement requirement-driven TWRS Characterization Program information and a list of tanks addressed in Fiscal Year 1997.

Winters, W. I., L. Jensen, L. M. Sasaki, R. L. Weiss, J. F. Keller, A. J. Schmidt, and M. G. Woodruff, 1989, *Waste Characterization Plan for the Hanford Site Single-Shell Tanks*, WHC-EP-0210, Westinghouse Hanford Company, Richland, Washington.

Flesher, D. J., and R. N. Kersey, 1980, *Hanford Defense High-Level Waste Sampling and Characterization Plan*, RHO-CD-573, Rockwell Hanford Company, Richland, Washington.

- Discusses early characterization planning documents.

Christensen, W. R., 1975, *Tank Farm Sludge Samples*, (internal letter [number unknown] to J. A. Teal, November 18), Atlantic Richfield Hanford Company, Richland, Washington.

- Lists tanks to be sampled, November 1975 to March 1976.

Homi, C. S., 1996, *Vapor Sampling and Analysis Plan*, WHC-SD-WM-TP-335, Rev. 2D, Westinghouse Hanford Company, Richland, Washington.

- Vapor sampling and analysis procedure for 200 Area tanks.

DOE-RL, 1996, *Recommendation 93-5 Implementation Plan*, DOE/RL-94-0001, Rev. 1, U.S. Department of Energy Richland Operations, Richland, Washington.

- Describes the organic solvent issue in the 93-5 implementation plan.

Kupfer, M. J., W. W. Schultz, G. L. Borsheim, S. J. Eberlein, B. C. Simpson, and J. T. Slankas, 1994, *Strategy for Sampling Hanford Site Tank Wastes for Development of Disposal Technology*, WHC-SD-WM-TA-154, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Provides basis for selecting tanks for disposal needs.

Ie. Data Quality Objectives and Customers of Characterization Data

Turner, D. A., H. Babad, L. L. Buckley, and J. E. Meacham, 1995, *Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue*, WHC-SD-WM-DQO-006, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Applies to tanks that may contain elevated levels of organics. Describes testing necessary to determine whether an organic fuel issue exists for the tank.

Cash, R. J., 1996, *Scope Increase of Data Quality Objective to Support Resolution of the Organic Complexant Safety Issue*, Rev. 2, (internal memorandum 79300-96-029 to S. J. Eberlein, July 12), Westinghouse Hanford Company, Richland, Washington.

- Contains interim requirements for the organic solvents issue.

Fowler, K. D., 1995, *Data Quality Objectives for Tank Farms Waste Compatibility Program*, WHC-SD-WM-DQO-001, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Used to determine the compatibility of a waste stream with double-shell tank wastes.

Dukelow, G. T., J. W. Hunt, H. Babad, and J. E. Meacham, 1995, *Tank Safety Screening Data Quality Objective*, WHC-SD-WM-SP-004, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Used to determine whether tanks are operating under safe conditions.

Simpson, B. C., and D. J. McCain, 1996, *Historical Model Evaluation Data Requirements*, WHC-SD-WM-DQO-018, Rev. 1, Westinghouse, Hanford Company, Richland, Washington.

- Provides data needs for evaluating the Los Alamos National Laboratory model for estimating tank waste compositions.

Osborne, J. W., J. L. Huckaby, E. R. Hewitt, C. M. Anderson, D. D. Mahlum, B. A. Pulsipher, and J. Y. Young, 1995, *Data Quality Objectives for Generic In-Tank Health and Safety Vapor Issue Resolution*, WHC-SD-WM-DQO-002, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Osborne, J. W., and L. L. Buckley, 1995, *Data Quality Objectives for Tank Hazardous Vapor Safety Screening*, WHC-SD-WM-DQO-002, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

- Describes the sampling and analysis used to address tank vapor safety and health issues.

Slankas, T. J., M. J. Kupfer, and W. W. Schulz, 1995, *Data Needs and Attendant Data Quality Objectives for Tank Waste Pretreatment and Disposal*, WHC-SD-WM-DQO-022, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Documents the needs of the pretreatment function within TWRS.

II. ANALYTICAL DATA - SAMPLING OF TANK WASTE AND WASTE TYPES

IIa. Sampling of tank 241-S-111

Steen, F. H., 1996, *Tank 241-S-111, Cores 149 and 150, Analytical Results for the Final Report*, WHC-SD-WM-DP-195, Rev. 1, Rust Federal Services of Hanford, Inc., Richland, Washington.

- Contain sample analyses from 1996 tank 241-S-111 push core sampling event.

Huckaby, J. L., and D. R. Bratzel, 1995, *Tank 241-S-111 Headspace Gas and Vapor Characterization Results for Samples Collected in March 1995*, WHC-SD-WM-ER-507, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Jenkins, R. A., A. B. Dindal, C. Y. Ma, M. A. Palausky, J. T. Skeen, and C. K. Bayne, 1995, *Analysis of Tank 241-S-111 Headspace Components*, ORNL-CASD-FR-241S111.95, Rev. 0, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Caprio, G. S., 1995, *Vapor and Gas Sampling of Single-Shell Tank 241-S-111 Using the Vapor Sampling System*, WHC-SD-WM-RPT-143, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Klinger, G. S., T. W. Clauss, M. W. Ligotke, K. H. Pool, B. D. McVeety, K. B. Olsen, O. P. Bredt, J. S. Fruchter, and S. C. Goheen, 1995a, *Vapor Space Characterization of Waste Tank 241-S-111: Results from Samples Collected on 3/21/95*, PNL-10733 UC-606, Pacific Northwest Laboratory, Richland, Washington.

- Contains results from vapor samples obtained March 21, 1995.

Wilkins, N. E., R. E. Bauer, and D. M. Ogden, 1996, *Results of Vapor Space Monitoring of Flammable Gas Watch List Tanks*, HNF-SD-WM-TI-797, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

- Lists results of SHMS monitoring, vapor grab samples, and the March 21, 1995 vapor sample.

Buckingham, J. S., 1974, *Analysis of Sludge Sample From Tank 111-S*, (internal letter [number unknown], to W. R. Christensen, May 29), Atlantic Richfield Hanford Company, Richland, Washington.

- Describes results for one sludge sample that was very high in aluminum.

Horton, J. E., and J. S. Buckingham, 1974, *Analyses of Salt Sample From 242-S Evaporator Slurry Receiving Tanks 105-S, 106-S and 111-S*, (internal letter [number unknown] to N. L. Harms, August 23), Atlantic Richfield Hanford Company, Richland, Washington.

- Describes analytical results for salt and supernatant samples from tank 241-S-111.

Horton, J. E., 1977, *Analysis of Tank 111-S Salts*, (internal letter [number unknown] to W. R. Christensen, February 28), Atlantic Richfield Hanford Company, Richland, Washington.

Horton, J. E., 1977, *Engineering Assistance Waste Concentration*, (internal memorandum [number unknown] to D. C. Lini, June [no day provided]), Rockwell Hanford Company, Richland, Washington.

- Describes and provides results for salt sample taken December 27, 1976.

Horton, J. E., 1978, *Chemical and Physical Analysis of Core Segments from Tank 111-S*, (internal letter 60120-78-087 to G. K. Allen, August 25), Rockwell Hanford Operations, Richland, Washington.

Bratzel, D. R., 1980, *Evaluation of Waste Storage Tank Physical and Chemical Characterization Data*, (internal letter 65453-80-265 to F. M. Jungfleisch, September 18), Rockwell Hanford Operations, Richland, Washington.

- Describes analytical results on core sample taken between February and June 1978.

Wheeler, R. E., 1974, *Analysis of Tank Farm Samples*, (internal letter [number unknown] to R. L. Walser, December 16), Atlantic Richfield Hanford Company, Richland, Washington.

- Shows the results of one sample (100 percent solids) from tank 241-S-111.

Babad, H., and J. S. Buckingham, 1974, *Analyses of Solidified Salt Wastes and Associated Mother Liquors*, (internal letter [number unknown] to G. S. Barney and Distribution, September 5), Atlantic Richfield Hanford Company, Richland, Washington.

- Gives analytical results for a sample from tank 241-S-111.

Puryear, D. A., 1971, *Analysis of Tanks 110-S, 111-S, and 112-S*, (internal letter [number unknown] to J. O. Skolrud, July 20), Atlantic Richfield Hanford Company, Richland, Washington.

- Provides the results of samples taken for analysis and boildown.

Puryear, D. A., 1971, *Characterization of S, U, and SX Waste Tanks*," (internal letter [number unknown] to J. O. Skolrud, September 21), Atlantic Richfield Hanford Company, Richland, Washington.

- Contains analytical results for tank 241-S-111.

Christensen, W. R. 1974, *Sludge Sampling Status*, (internal letter [number unknown] to R. L. Walser, August 27), Atlantic Richfield Hanford Company, Richland, Washington.

- Gives heat generation and thermal conductivity data, along with analytical data for a sample reported August 23, 1974 (see Section IIa listing for Horton and Buckingham 1974).

IIb. Sampling of 242 S-Evaporator Waste Streams

- All information in this section is documented in Process Aids 1970 to 1993. Process Aids is a consecutive compilation of laboratory memoranda, letters, etc. indexed by year, by subject, and/or tank. The following analyses may provide insight as to the composition of the saltcake waste type expected to be in tank 241-S-111.

Jurgensmeier, C. A., 1991, *Results of Single-Shell/Double-Shell Data Research*, (internal memorandum 28110-PCL91-046, to H. Babad, May 30), Westinghouse Hanford Company, Richland, Washington.

Reynolds, D. A., 1982, *242-S Evaporator Crystallizer Third Partial Neutralization Campaign*, RHO-CD-1515, Rockwell Hanford Operations, Richland, Washington.

Babad, H., 1974, *Analysis of Solidified Salt Wastes and Associated Mother Liquors*, (internal letter [number unknown] to G. S. Barney, September 5), Atlantic Richfield Hanford Company, Richland, Washington.

Cain, R. J., 1974, *Dry Saltcake Composition,* (internal letter [number unknown] to R. E. Vander Cook, October 18), Atlantic Richfield Hanford Company, Richland, Washington.

Wheeler, R. E., 1974, *Dry Saltcake Composition*, (internal letter [number unknown] to R. E. Vander Cook, October 18), Atlantic Richfield Hanford Company, Richland, Washington.

Sant, W. H., 1973, *242-S Feed Samples Number T-9494*, (internal letter [number unknown] to R. L. Walser, December 18), Atlantic Richfield Hanford Company, Richland, Washington.

III. COMBINED ANALYTICAL/NON-ANALYTICAL DATA

IIIa. Inventories from Campaign and Analytical Information

Agnew, S. F., J. Boyer, R. A. Corbin, T. B. Duran, J. R. Fitzpatrick, K. A. Jurgensen, T. P. Ortiz, and B. L. Young, 1997, *Hanford Tank Chemical and Radionuclide Inventories: HDW Model Rev. 4*, LA-UR-96-3860, Rev. 0, Los Alamos National Laboratory, Los Alamos, New Mexico.

- Contains waste type summaries and primary chemical compound/analyte and radionuclide estimates for sludge, supernatant, and solids.

Allen, G. K., 1976, *Estimated Inventory of Chemicals Added to Underground Waste Tanks, 1944 - 1975*, ARH-CD-601B, Atlantic Richfield Hanford Company, Richland, Washington.

- Contains major components for waste types and some assumptions. Purchase records are used to estimate chemical inventories.

Geier, R. G., 1976, *Estimated Hanford Liquid Wastes Chemical Inventory as of June 30, 1976*, ARH-CD-768, Atlantic Richfield Hanford Company, Richland, Washington.

- Waste tank inventory estimates.

Allen, G. K., 1975, *Hanford Liquid Waste Inventory As Of September 30, 1974*, ARH-CD-229, Atlantic Richfield Hanford Company, Richland, Washington.

- Contains major components for waste types and some assumptions.

IIIb. Compendium of Data from Other Sources Physical and Chemical

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1995, *Tank Waste Source Term Inventory Validation, Vol I & II.*, WHC-SD-WM-ER-400, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains a quick reference to sampling information in spreadsheet or graphical form for 23 chemicals and 11 radionuclides for all tanks.

Brevick, C. H., L. A. Gaddis, and E. D. Johnson, 1994, *Historical Tank Content Estimate for the Southwest Quadrant of the Hanford 200 Areas*, WHC-SD-WM-ER-352, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains summary information from the supporting document and in-tank photo collages and the solid composite inventory estimates Rev. 0 and Rev. 0A.

Brevick, C. H., L. A. Gaddis, and W. W. Pickett, 1994, *Supporting Document for the Historical Tank Content Estimate for S Farm*, WHC-SD-WM-ER-323, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Contains summary tank farm and tank write-ups on historical data and solid inventory estimates as well as appendixes for the data. The appendixes contain the following information: Appendix C - Level History AutoCAD sketch; Appendix D - Temperature Graphs; Appendix E - Surface-Level Graph; Appendix F, pp. F-1 - Cascade/Drywell Chart; Appendix G - Riser Configuration Drawing and Table; Appendix I - In-Tank Photos; and Appendix K - Tank Layer Model Bar Chart and Spreadsheet.

Hanlon, B. M., 1996, *Waste Tank Summary Report for Month Ending October 31, 1996*, WHC-EP-0182-103, Westinghouse Hanford Company, Richland, Washington.

- Contains a monthly summary of the following: fill volumes, Watch List tanks, occurrences, integrity information, equipment readings, equipment status, tank location, and other miscellaneous tank information.

McCann, D. C., 1982, *Waste Status Summary*, RHO-RE-SR-14, Rockwell Hanford Company, Richland, Washington.

- Summarizes tank waste status as of April 30, 1982. Lists method used to establish tank 241-S-111 waste volume estimate at that time.

Welty, R. K., 1988, *Waste Storage Tank Status and Leak Detection Criteria*, WHC-SD-WM-TI-356, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Provides historical surveillance data, including drywell activity and tank liquid levels.

Husa, E. I., 1993, *Hanford Site Waste Storage Tank Information Notebook*, WHC-EP-0625, Westinghouse Hanford Company, Richland, Washington.

- Contains in-tank photos and summaries of the tank description, leak detection system, and tank status.

Husa, E. I., 1995, *Hanford Waste Tank Preliminary Dryness Evaluation*, WHC-SD-WM-TI-703, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

- Assesses relative dryness between tanks.

Klem, M. J., 1990, *Total Organic Carbon Concentration of Single-Shell Tank Waste*, (internal memorandum 82316-90-032 to R. E. Raymond, April 27), Westinghouse Hanford Company, Richland, Washington.

- Estimates TOC concentrations for single-shell tanks.

Wheeler, R. E., 1975, *Analysis of Tank Farm Samples for Chloride*, (internal letter [number unknown] to R. L. Walser, May 29), Atlantic Richfield Hanford Company, Richland, Washington.

- Gives chloride concentration for various single-shell tanks.

Shelton, L. W., 1996, *Chemical and Radionuclide Inventory for Single- and Double-Shell Tanks*, (internal memorandum 74A20-96-30 to D. J. Washenfelder, February 28), Westinghouse Hanford Company, Richland, Washington.

- Contains tank inventory estimates based on analytical information developed by pretreatment and disposal organizations.

Van Vleet, R. J., 1993, *Radionuclide and Chemical Inventories for the Double-Shell Tanks*, WHC-SD-WM-TI-543, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Carpenter, B. C., 1993, *Radionuclide and Chemical Inventories for the Single-Shell Tanks*, WHC-SD-WM-TI-565, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Provides radionuclide and chemical inventories developed by safety organizations.

Kummerer, M., 1995, *Heat Removal Characteristics of Waste Storage Tanks*, WHC-SD-WM-SARR-010, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

- Estimates heat load for each tank.

Dixon, D. R., 1977, *Evaluation of the 241-S-111 Salt Well Jet Pump Prototype*, RHO-CD-80, Rockwell Hanford Company, Richland, Washington.

- Discusses salt well pumping of tank 241-S-111.

LMHC, 1997, Surveillance Analysis Computer System database, January 21, 1997, Tank Farm Surveillance Engineering, Lockheed Martin Hanford Corporation, Richland, Washington.

- Surveillance data for all tanks including temperature, surface level, and interstitial liquid level.

This page left blank intentionally.

DISTRIBUTION SHEET

To	From	Page 1 of 2
Distribution	Data Assessment and Interpretation	Date 04/28/97
Project Title/Work Order		**EDT No.** EDT-617600
Tank Characterization Report for Single-Shell Tank 241-S-111, HNF-SD-WM-ER-638, Rev. 0		**ECN No.** N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
<u>OFFSITE</u>					
<u>Sandia National Laboratory</u> P.O. Box 5800 MS-0744, Dept. 6404 Albuquerque, NM 87815					
D. Powers		X			
<u>Nuclear Consulting Services Inc.</u> P. O. Box 29151 Columbus, OH 43229-01051					
J. L. Kovach		X			
<u>Chemical Reaction Sub-TAP</u> P.O. Box 271 Lindsborg, KS 67456					
B. C. Hudson		X			
<u>SAIC</u> 20300 Century Boulevard, Suite 200-B Germantown, MD 20874					
H. Sutter		X			
<u>Los Alamos Laboratory</u> CST-14 MS-J586 P. O. Box 1663 Los Alamos, NM 87545					
S. F. Agnew		X			
<u>Los Alamos Technical Associates</u> T. T. Tran	B1-44	X			
<u>Tank Advisory Panel</u> 102 Windham Road Oak Ridge, TN 37830					
D. O. Campbell		X			

THIS PAGE INTENTIONALLY
LEFT BLANK

DISTRIBUTION SHEET

To	From	Page 2 of 2
Distribution	Data Assessment and Interpretation	Date 04/28/97
Project Title/Work Order		EDT No. EDT-617600
Tank Characterization Report for Single-Shell Tank 241-S-111, HNF-SD-WM-ER-638, Rev. 0		ECN No. N/A

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
ONSITE					
Department of Energy - Richland Operations					
J. F. Thompson	S7-54	X			
W. S. Liou	S7-54	X			
J. A. Poppiti	S7-54	X			
N. W. Willis	S7-54	X			
DE&S Hanford, Inc.					
R. J. Cash	S7-14	X			
W. L. Cowley	R2-54	X			
G. L. Dunford	A2-34	X			
G. D. Johnson	S7-14	X			
J. E. Meacham	S7-14	X			
Fluor Daniel Northwest					
J. L. Stroup	S3-09	X			
Lockheed Martin Hanford, Corp.					
J. M. Conner	R2-12	X			
K. M. Hodgson	H0-34	X			
T. J. Kelley	S7-21	X			
L. M. Sasaki	R2-12	X			
B. C. Simpson	R2-12	X			
L. R. Webb	R2-12	X			
ERC (Environmental Resource Center)	R1-51	X			
T.C.S.R.C.	R1-08	5			
Lockheed Martin Services, Inc.					
B. G. Lauzon	R1-08	X			
Central Files	A3-88	X			
EDMC	H6-08	X			
Numatec Hanford Corporation					
J. S. Garfield	H5-49	X			
J. S. Hertzel	H5-61	X			
D. L. Lamberd	H5-61	X			
Pacific Northwest National Laboratory					
A. F. Noonan	K9-91	X			
Rust Federal Services of Hanford, Inc.					
C. T. Narquis	T6-16	X			

THIS PAGE INTENTIONALLY
LEFT BLANK